TOBER 1960
ME 3 • NUMBER 10

- Cohn — Phase-Shift and Time-Delay Response of Microwave Narrow-Band Filters
- Lax & Button — Electromagnetic Properties of Ferrimagnetics and Their Applications from UHF to Millimeter Waves — Part II
- Richter — Millimeter Radiometers
- Currie, Young, Gosnell — Conducting Fabric Antennas

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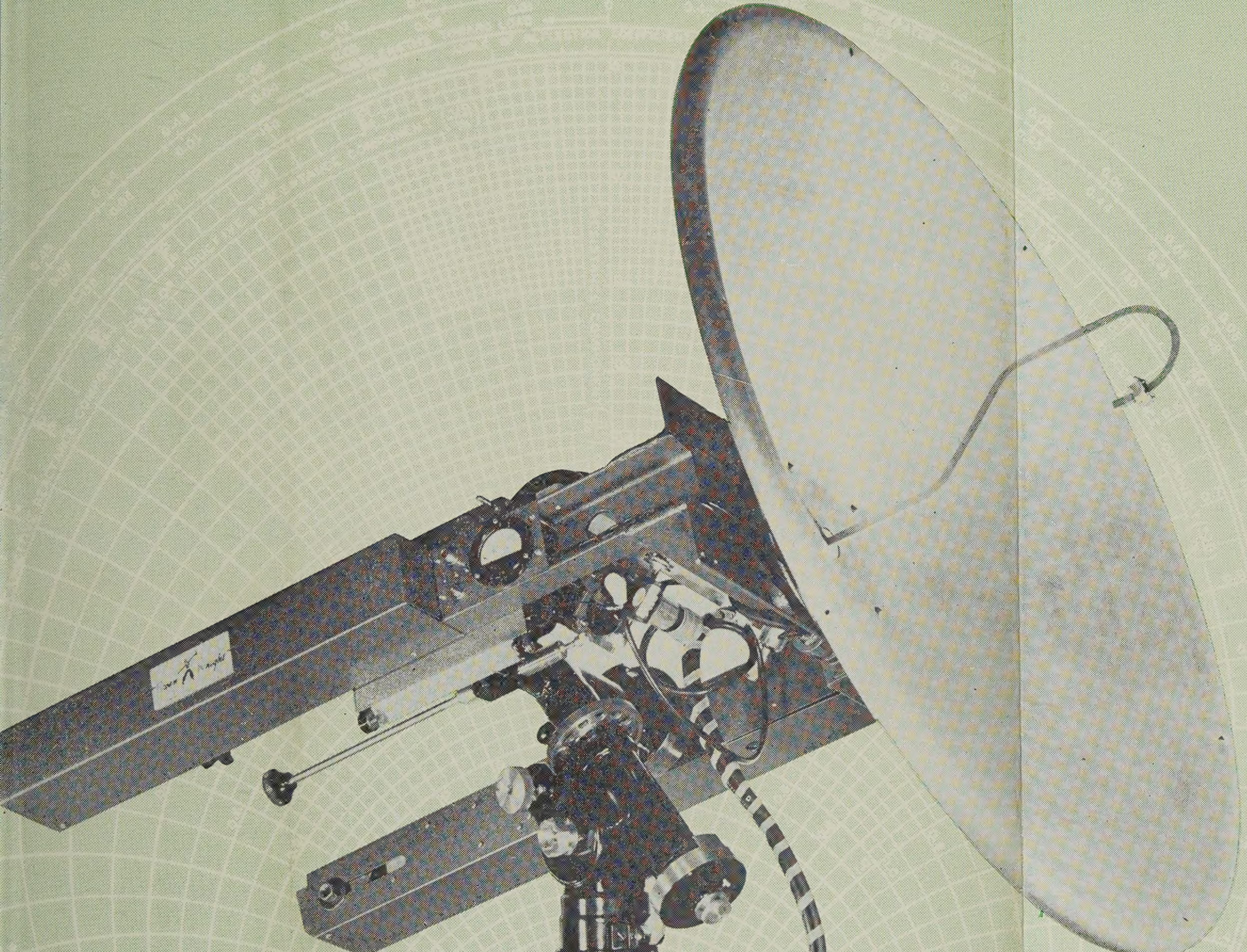

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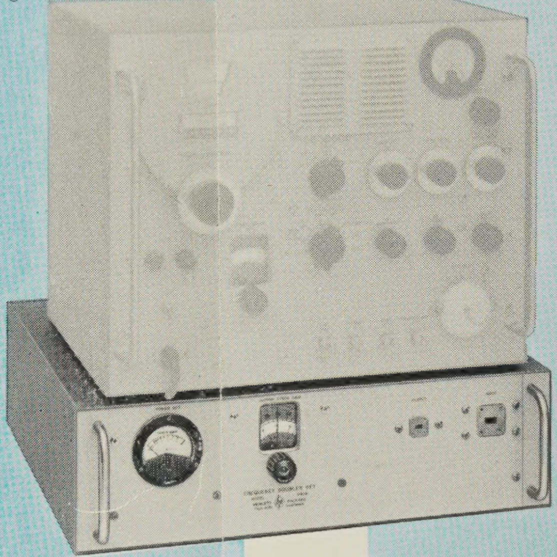
W. W. HANSEN BIOGRAPHY

Now! GENERATE PRECISE SIGNALS TO 40 KMC



with these new, inexpensive

FREQUENCY DOUBLER SETS!

For convenient, economical, reliable signal generation to 40 KMC, use these new hp Frequency Doubler Sets and either your own existing signal sources or one of the dependable, bench-proven hp signal generators on the next pages.

hp Model 938A supplies power from 18 to 26.5 KMC when driven by a 9 to 13.25 KMC source; hp Model 940A supplies power from 26.5 to 40 KMC when driven by a 13.25 to 20 KMC source.

The hp 938A and 940A have the same output versatility as the driving source. These broadband instruments accept cw, pulsed or swept input signals from signal generators, swept signal sources or klystrons.

Each contains a broadband crystal-harmonic generator, plus a dual rotary vane attenuator, for generating and accurately setting the output level 0 to —100 dbm. Output power depends on input power and is typically 0.5 to 1.0 mw when the driving source is an hp 626A or 628A Signal Generator or an hp 686A Sweep Oscillator. Output power is known, even though an uncalibrated signal source is used, since the output monitor is accurate to ± 1 to ± 2 db, depending on model and frequency.

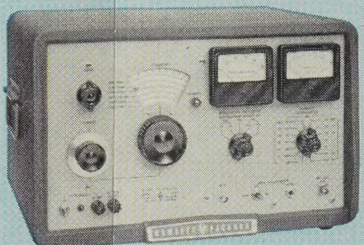
hp 938A/940A conversion loss is approximately 17 db at 10 mw input. Maximum input power 200 mw, saturation output 2 mw. Attenuator accuracy ± 2% of reading or 0.2 db (whichever is greater). Attenuator range 100 db; output SWR less than 1.2 at 10 db or more attenuation. Sturdy construction permits signal source to be mounted on top of Doubler Set, presents output at convenient bench level. hp 938A, $1,500.00; hp 940A, $1,500.00.

Check these Precision hp SIGNAL GENERATORS

FULL COVERAGE

hp 606A Standard Signal Generator
50 KC to 65 MC

utput adjustable from 3 v full range to 0.1 μv rms (+23 to −120 bm). Feedback assures power into a 50 ohm load constant within ± db over the frequency range. Reliable internal crystal calibrator ermits checking points at 100 KC and 1 MC intervals with an error f less than 0.01%. Very low distortion, broad modulating capabiliies. Typical hp speed, ease of operation. hp 606A, $1,200.00.



VHF SIGNAL GENERATORS

hp 608D—10 to 420 MC

lighest stability, low incidental FM and frequency drift. Calirated output 0.1 μv to 0.5 v throughout range. Built-in crystal alibrator provides frequency check accurate within 0.01% each 1 nd 5 MC. Master-oscillator, buffer and output amplifier circuit degn. Direct calibration, ideal for aircraft communications equipment esting. hp 608D, $1,100.00.

hp 608C—vhf Signal Generator

igh power (1 v max.), stable, accurate generator. 10 to 480 MC. deal for testing receivers, amplifiers, driving bridges, slotted lines, ntennas, etc. hp 608C, $1,000.00.

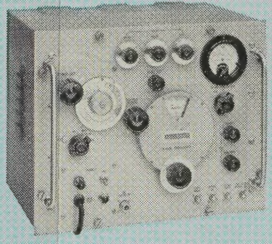
UHF SIGNAL GENERATORS

hp 612A—450 to 1,230 MC

Same high output power, low incidental FM, broad modulation apabilities as hp vhf signal generators. Frequency, output directly et on large precisely calibrated dials. hp 612A, $1,200.00.

hp 614A—800 to 2,100 MC

Easy to use, direct-reading, one-dial frequency control, high staility and accuracy. Ideal for measuring receiver sensitivity, signaloise ratio, conversion gain, SWR, transmission line characteristics. hp 614A, $1,950.00.



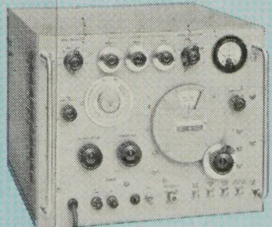
hp 616B—1,800 to 4,200 MC

Ruggedly built, compact to save bench space, offers same hp precision, ease of operation, compactness of the other hp uhf instruments. hp 616B, $1,950.00.

SHF SIGNAL GENERATORS

hp 618B—3,800 to 7,600 MC
hp 620A—7,000 to 11,000 MC

These instruments provide the simple, versatile operation and varied ulsing capabilities common in hp signal generators to the lower egions of the shf range. The 618B and 620A may be synchronized vith an external sine wave or with positive or negative pulse signals, s may other hp signal generators. hp 618B, $2,250.00; hp 620A, 2,250.00.



50 KC TO 40 KMC

VERSATILE GENERATORS, OSCILLATORS ALSO DRIVE hp FREQUENCY DOUBLER SETS

hp 626A/628A shf Signal Generators

Instruments bringing high power, wide range, convenience and accuracy to the 10 to 21 KMC range. Frequencies, output voltage directly set and read. Output 10 to 20 db better than previous spot-frequency sets; SWR better than 1.2 at 0 dbm and lower. High power output provides excellent drive for the hp 938A/940A Frequency Doubler Sets. Internal pulse, FM or square wave modulation; also external pulsing or FM'ing. hp 626A, 10 to 15.5 KMC, $3,250.00; hp 628A, 15 to 21 KMC, $3,250.00.

hp 680 Series Sweep Oscillators

Five models offering electronic sweeping for greater flexibility, simplified operation; range from 1 to 18.0 KMC. hp 686A, 8.2 to 12.4 KMC and hp 687A, 12.4 to 18.0 KMC, useful for driving hp Frequency Doubler Sets. hp 682A 1-2 KMC, $3,090.00; hp 683A, 2 to 4 KMC, $3,000.00; hp 684B, 4.0 to 8.1 KMC, $2,900.00; hp 686A, $2,900.00; hp 687A, $3,400.00.

Instrument	Frequency Range	Characteristics	Price
hp 606A	50 KC to 65 MC	Output 0.1 µv to 3 v. Full feedback loop, low distortion	$1,200.00△
hp 608C	10 to 480 MC	Output 0.1 µv to 1 v into 50 ohm load. AM, pulse, or CW modulation. Direct calibration	1,000.00■
hp 608D	10 to 420 MC	Output 0.1 µv to 0.5 v. Incidental FM less than 0.001%	1,100.00■
hp 612A	450 to 1,230 MC	Output 0.1 µv to 0.5 v into 50 ohm load. AM, pulse, CW or square wave modulation. Direct calibration	1,200.00■
hp 614A	800 to 2,100 MC	Output 0.1 µv to 0.223 v into 50 ohm load. Pulse, CW or FM modulation. Direct calibration	1,950.00■
hp 616B	1,800 to 4,200 MC	Output 0.1 µv to 0.223 v into 50 ohm load. Pulse, CW or FM modulation. Direct calibration	1,950.00■
hp 618B	3,800 to 7,600 MC	Output 0.1 µv to 0.223 v into 50 ohm load. Pulse, CW FM or square wave modulation. Direct calibration	2,250.00■
hp 620A	7,000 to 11,000 MC	Output 0.1 µv to 0.223 v into 50 ohm load. Pulse, FM or square wave modulation. Direct calibration	2,250.00■
hp 626A	10 to 15.5 KMC	Output 10 dbm to —90 dbm. Pulse, FM, or square wave modulation. Direct calibration	3,250.00■
hp 628A	15 to 21 KMC	Output 10 dbm to —90 dbm. Pulse, FM, or square wave modulation. Direct calibration	3,250.00■

△Rack mounted instruments $15.00 less.
■Rack mounted instruments $20.00 additional.

Data subject to change without notice. Prices f.o.b. factory.

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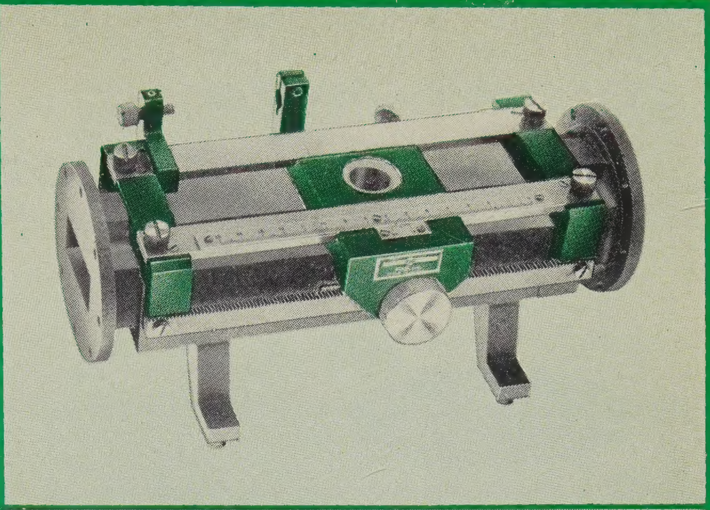
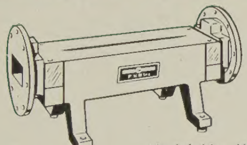
Interchangeable SLOTTED SECTIONS

convenient and positive

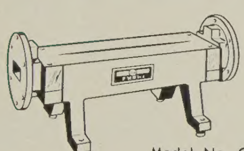


- conveniently interchangeable waveguide sections
- no slope adjustment required
- vernier position scale readable to 0.1 mm.
- dial gauge holder and movable stop
- tapered slots to minimize residual VSWR

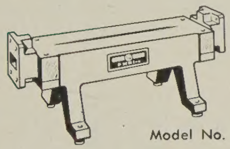
INTERCHANGEABLE WAVEGUIDE SECTIONS



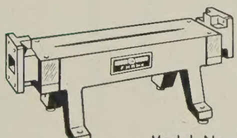
Model No. H115A



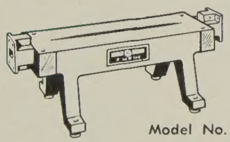
Model No. C115A



Model No. W115A

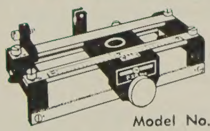


Model No. X115A



Model No. Y115A

UNIVERSAL CARRIAGE



Model No. Z116A

Like the finest camera with a precisely fitted set of lenses, the FXR Universal Carriage and family of five Interchangeable Slotted Sections are matched to perfection. "Togetherness" with this unrivalled modular waveguide system gains new meaning . . . more rapid interchange of each section without tools or need for alignment, and more dependable performance over the entire frequency range from 3.95 kmc to 18.00 kmc. Another fine FXR "package" with quality and reliability built into it—from the first mark on the drawing board.

SERIES 115 PRECISION SLOTTED SECTIONS

MODEL NO.	FREQUENCY RANGE (KMC)	WAVEGUIDE DIMENSIONS (Inches)	INSERTION LENGTH	WAVEGUIDE TYPE	FLANGE TYPE
H115A	3.95- 5.85	2 x 1	10⅜ in.	RG-49/U	UG-149A/U
C115A	5.85- 8.20	1½ x ¾	10⅜ in.	RG-50/U	UG-344/U
W115A	7.05-10.00	1¼ x ⅝	10⅜ in.	RG-51/U	UG-51/U
X115A	8.20-12.40	1 x ½	10⅜ in.	RG-52/U	UG-39/U
Y115A	12.40-18.00	0.622 x 0.311 ID	10⅜ in.	RG-91/U	UG-419/U

ACCESSORY: FXR Model No. B200A Tunable Probe.
All units when mounted in Z116A Carriage:
Slope—1.01 max. Irregularity—1.005 max.

Write for Bulletin No. SS115 or contact your local FXR representative.

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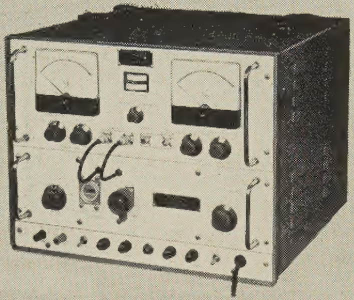
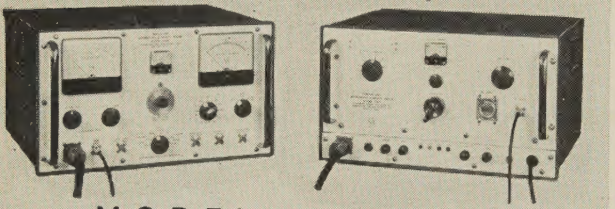
UNIT TEST APPROACH

For measurement of microwave and i.f. stability . . .



MODEL
5004
Microwave Stability Tester



MODEL
5009 **Microwave Stability Tester**
(Indicator plus power supply)

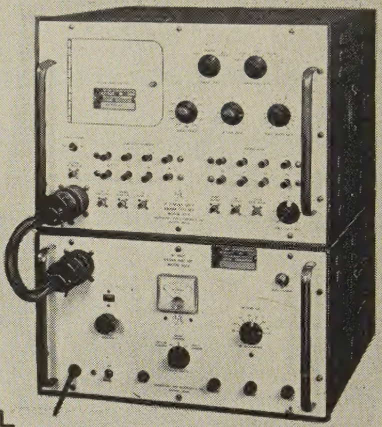
. . . .

For measurement of pulse jitter in comparator . . .

MODEL
5015 **Time Stability Tester**

SYSTEM TEST APPROACH

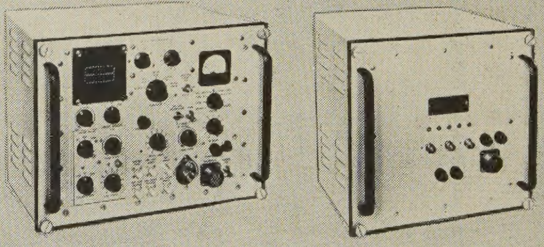
For direct db measurement of overall subclutter visibility at r.f., i.f., video . . .



MODEL
5012 **MTI Radar Tester**

. . . .

For measuring System, Receiver and Comparator subclutter visibility in X-band airborne MTI systems . . .



MODEL
5014 **MTI Radar Tester/GO-NO-GO Checker**
(Indicator plus power supply)

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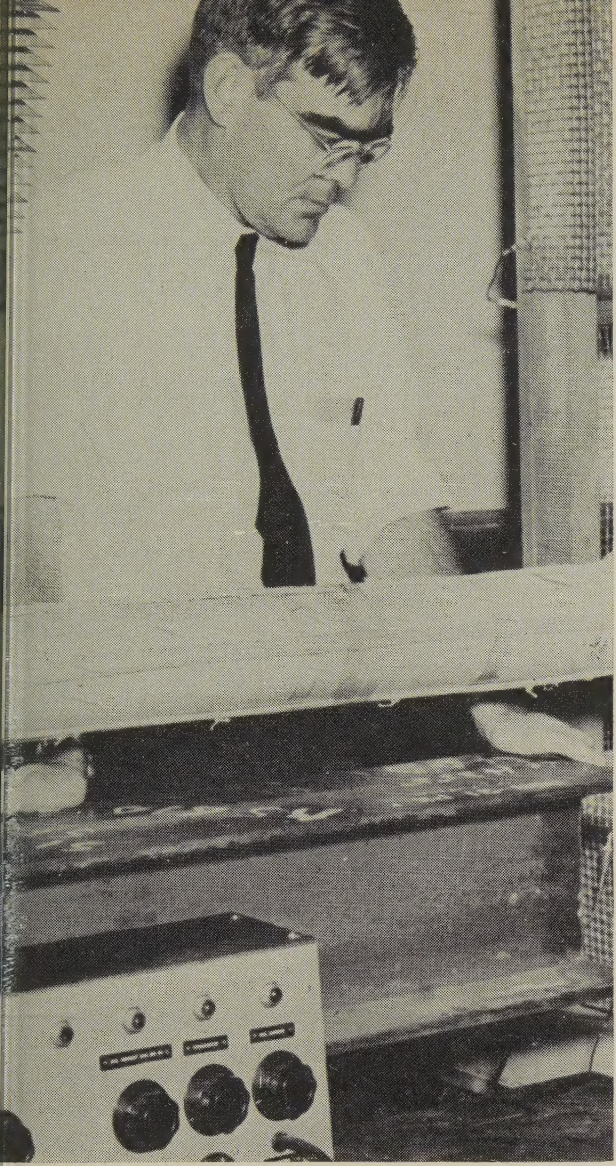


TRIBUTE

to an

UNCOMMON MAN

William Webster Hansen

By DAVID H. SIMON

"The name of William Webster Hansen will never be a household byword.

"Had he been a professional ball player, an author or an actor, he would have been known to far more people. His talent, in these more colorful fields, would have won wider recognition and more acclaim.

"As it was, his achievements were not the kind that make newspaper headlines. William Hansen was a scientist . . . and science, even in our technological age, is not nearly so exciting to read about as the progress of the World Series, or the escapades of a famous movie actress.

"Nevertheless, he made an uncommon contribution to the century in which he was born.

"What William Hansen did, like other men of science down through the long calendar of human progress, was to carve out of the unknown darkness of physical law a number of salient truths, then develop them in ways that would serve a whole civilization."

Thus, a few years after his death, did Stanford University pay tribute to one of its greatest professors.

This, then, is the story of an Uncommon Man.

William Hansen was born on May 27, 1909, in Fresno, California, the son of a machine tool expert who was to endow his boy with the rare ability of building in the shop the devices he created on paper. Young Hansen remained in Fresno through high school, where his teachers noted that he was an exceptional student and recorded his marked facility in science and mathematics.

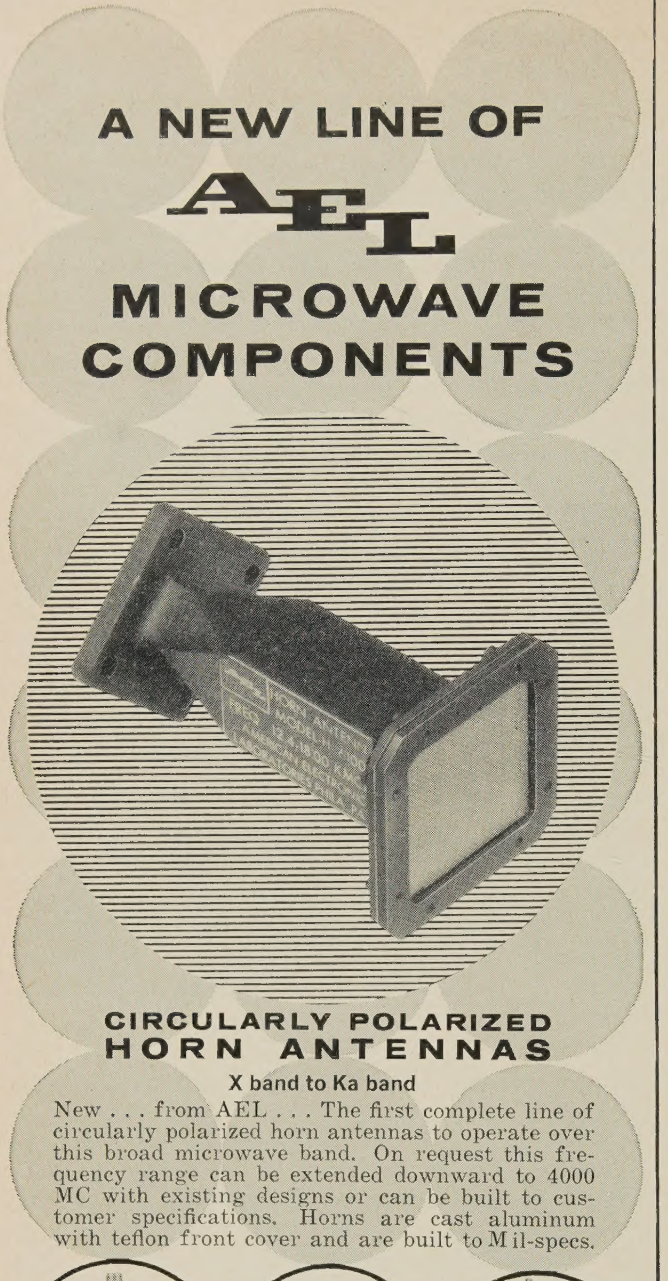
College would not be so easy. Qualification for admission was no problem; finances were. His father, who provided him with inspiration, an inquisitive mind and manual dexterity, was unable to provide more than token assistance where funds were concerned.

In 1925 the tuition rate at Stanford was $288. Bill Hansen had only $280. An E. C. Converse Scholarship for "needy and deserving students" made possible his freshman year of electrical engineering. But the going was rough. Brilliant in science and math, he was sadly lacking in language ability. He struggled briefly with Spanish, gave up, switched to German and ended his first year with an "incomplete" in that subject. As a result, he lost out in the keen competition for another scholarship. Bitterly disappointed, he returned home and entered Fresno State College, for his second year.

Harry Burbridge, Chairman of the Fresno State physics department, recalls, "He came into my class in Physics and, though it was a large one, his ability stood out almost immediately. I soon discovered he already knew far more physics than was covered in this class and told him he need not attend class unless he cared to, but could come and take the examinations when they were given. Mr. Hansen was still planning to go on with the course in electrical engineering, but in the second semester I

(*Continued on page 12*)

Inspiration and some of the material for this article (including the initial quotation) was obtained from the booklet, "The Uncommon Man," copyright 1951 by Stanford University. The booklet takes its name from a forward by former President Herbert Hoover which calls on America to concentrate on finding uncommon men to lead it in this "Century of the Common Man." Permission for its use is gratefully acknowledged.



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X band to Ka band

New . . . from AEL . . . The first complete line of circularly polarized horn antennas to operate over this broad microwave band. On request this frequency range can be extended downward to 4000 MC with existing designs or can be built to customer specifications. Horns are cast aluminum with teflon front cover and are built to Mil-specs.

Coaxial crystal detector mounts • 50 mc to 12 kmc

Waveguide Filters Band Pass and High Pass • 8.2 kmc to 40 kmc

Conical Helix and Log Periodic Antennas Broad Band 40 mc to 12 kmc

Waveguide Crystal Detector Mounts • 8.2 kmc. to 40 kmc. aluminum high tangential sensitivities

Coaxial Microwave Crystal Switches • 30 mc to 12 kmc

Waveguide Dummy Loads • Low VSWR Lightweight—High Power—High Efficiency

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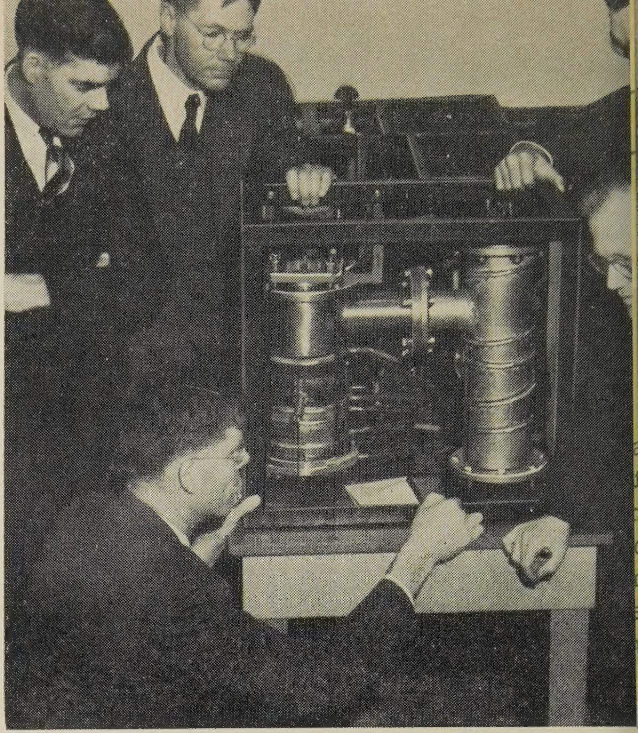

In this 1939 photo, Hansen (right rear) inspects klystro
which he helped invent while at Stanford University. Lookin
on are, left to right, co-inventors Professor David L. Webste,
Sigurd Varian, Russel Varian (kneeling), and builder John F
Woodyard.

Hansen

(*Continued from page 11*)

talked over his future with him and suggested that wit
his type of mind he should go into physical researcl
This he finally agreed to, and on that basis I wrote Pro
fessor David L. Webster and asked if the Physics De
partment at Stanford might not offer him an assistantshi
I remember stating in my letter that here was a youn
man of 22 years of age with a 30-year-old's mind whic
I considered quite remarkable." The plea was answere
and Bill completed his undergraduate studies in physic
at Stanford on a Dickey Scholarship, endowed "to ai
young men from Fresno County, preferably Fresno Cit
to make their way through Stanford University."

After completing his undergraduate training he r
mained at Stanford, first as a graduate assistant, teachin
some course he had never taken, and later as a Ph
candidate, taking some of the same courses. His oral e
amination for the Doctorate is still remembered at Sta
ford: so distinguished had been his work that the com
mittee saw fit to ask only two questions, one in his majo
field of physics, the other in mathematics, his minor. Th
first was "What was Galileo's first name?" (The answe
as Hansen knew, is that his first name was Galile
Galilei was the patronymic.) The second question i
volved a problem in integral calculus. Bill did it in h
head. In 1933, when his Doctorate was awarded, he w
considered one of the brightest intellects ever to achie
the degree at Stanford.

A brief period at Massachusetts Institute of Technolog
and the University of Michigan followed, after whic
Hansen returned to Stanford as an assistant professor

(*Continued on page 14*)

Creative Microwave Technology

Published by MICROWAVE AND POWER TUBE DIVISION, RAYTHEON COMPANY, WALTHAM 54, MASS., Vol. 2, No. 3

RAYTHEON 1,000,000-WATT MAGNETRON LOGS OVER 13,000 HOURS IN MOBILE RADAR

is is the first reported history of a ytheon QK-358 magnetron substantiated th an exhibit. Still, there are numrous other cases in which these excepnal Raytheon tubes have been clocked excess of 10,000 hours, radiating at ak power.

e case in point concerns the applican of a QK-358 magnetron in an AN/FPS-8 dar, for which the General Electric Comny is the prime contractor. When the be was replaced after 13,000 hours of rvice for "preventative maintenance" asons, it was returned to Raytheon where tube was found to be operating within ecifications. Findings showed it to be ghly stable and still capable of radiatg more than one megawatt of power.

large measure of the reliable operation d outstanding life of the QK-358 was hieved through special attention given its unique characteristics in the overl design of the radar transmitter.

r your information, the QK-358 is a meanically tunable pulsed-type oscillar with an integral magnet and is designed r coupling to a standard 3" x 6" waveide. Typical operating characteriscs include:

equency Range	"L" Band
ak Power Output	1.3 Mw
erage Power Output	1,630 W

DISTRIBUTION TRAILER
ANTENNA
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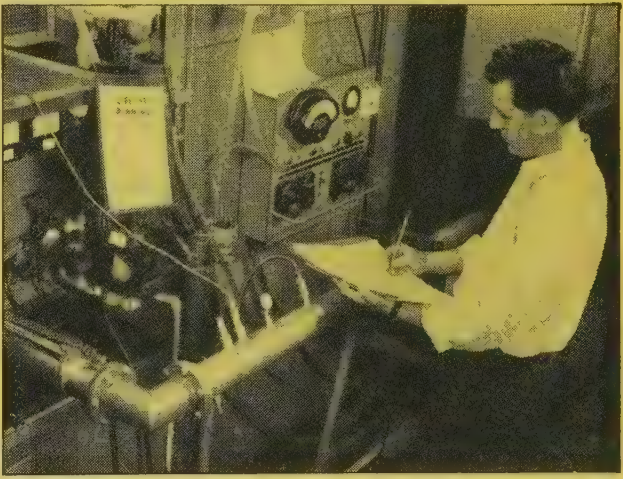
POWER EQUIPMENT

AN/FPS-8 high-power search system by General Electric, used primarily in aircraft control and early-warning operation. The complete mobile version (AN/MPS-11A) shown here, can be airlifted or carried on nine trucks and two trailers.



Life testing of Raytheon tubes, such as the QK-358 magnetron, for six weeks or more serves as a quality check of their performance characteristics as recorded and plotted against time.

Excellence in Electronics

You can obtain detailed application information and special development services by contacting: Microwave and Power Tube Division, Raytheon Co., Waltham 54, Mass. In Canada: E. Waterloo, Ontario. In Europe: Zurich, Switzerland.

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Circle Reader Service Card 8

TAPCO MICROWAVE COMPONENTS

Ku Band Waveguide Switches

These new TAPCO components fulfill a critical switching function in an advanced missile system and are now available to industry for general Ku Band applications.

Attenuator Switch H4P1AA
Rotary-type Switch H4P2CA
Shuttle-type Switch GI4P2AA

SPECIAL FEATURES

The shuttle switch permits switching under full power and when used in conjunction with the auxiliary attenuator switch provides 120 db isolation.

The attenuator switch when used separately provides 80 db isolation, low VSWR, and negligible insertion loss.

The rotary switch is a high-performance, fast-acting, failsafe device with low VSWR and insertion loss.

These features are available from TAPCO in switches covering all frequency ranges. Data sheets available on request.

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Circle Reader Service Card 9

Using new radio principle perfected at Stanford Univers (1939), Hansen tests a unit of the klystron.

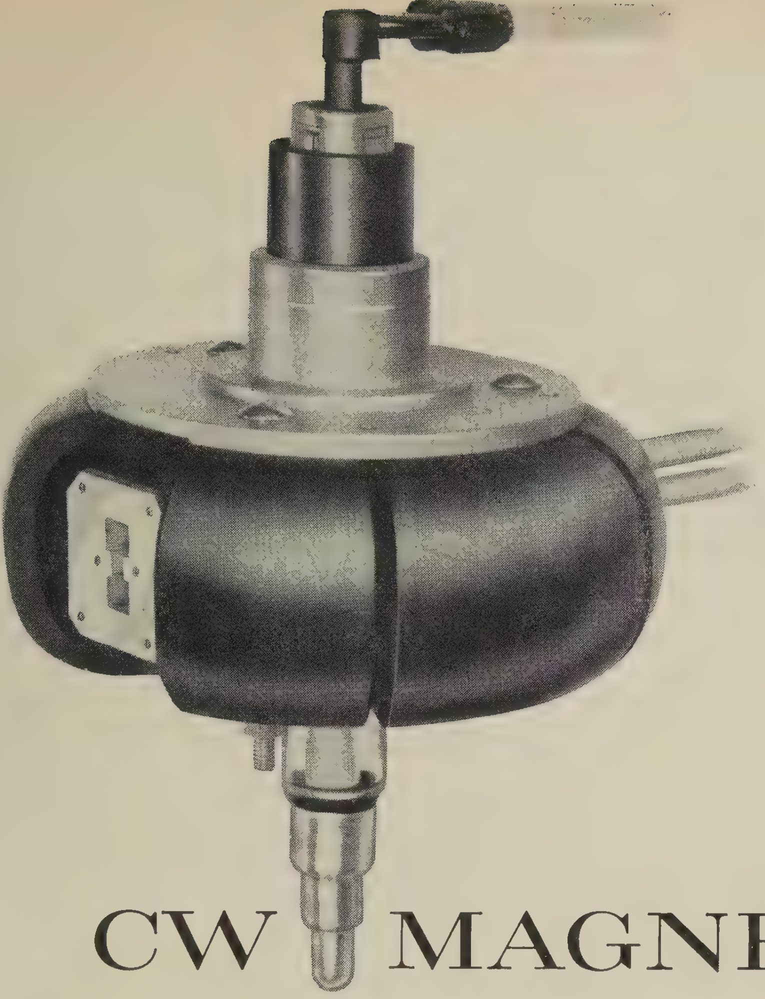
Hansen

(*Continued from page 12*)

physics. Inspired by Chadwick's discovery of the neutr Hansen began a search for a means of generating hig voltage X-rays. He found he needed rather high fr quencies, and although he was convinced that he cou make use of some type of resonant circuit, he was forc to reject the conventional L-C circuit because of the lo powers attainable at higher frequencies. Instead, he i vented the rumbatron, or cavity resonator.

While he was engaged in his work, two brothers a rived at Stanford with what seemed to be an insolub problem. The brothers, Russel (an engineer), and Sigu Varian (an airline pilot), were searching for a devi which would enable pilots to see in the dark. This, Ru knew, would require frequencies on the order of 5 megacycles or greater, but they were not able to devise source of sufficiently high power at the necessary fr quency. Hansen, challenged, took the brothers under h wing, provided guidance, counsel and when necessar encouragement. With this new stimulation the Varians last began to make headway. Rus conceived the idea velocity modulation using Hansen's resonant elemen principle, and with that as a starting point the brothe developed a series of possible designs. Each design, soon as it was completed, was rushed in to Dr. Hanse who would proceed to poke it full of holes. To assu that no possibility was over-looked, Rus methodicall categorized every conceivable approach, and set out t analyze each, one at a time. Ironically, shortly afterwar

(*Continued on page 16*)



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Type Number	Frequency Range Megacycles	Minimum Power Watts
L-3456	350-590	500
L-3459	590-975	500
L-3465	975-1500	400
L-3464	1500-2350	400
L-3460	2350-3575	500
L-3461	3575-4975	400
L-3467	4975-6175	400
L-3468	6175-7275	300
L-3462	7275-8775	300
L-3463	8775-10,475	250

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Item No.	Model No.	Frequency Range	Power Output	Operating Voltage	Operating Current
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1	35V10	33~37KMC	40mW	2,000V	12mA
2	35V11	33~37	100	2,000	25
3	50V10	43~51	40	2,300	25
4 *	70V10	65~75	15	3,500	30
—Magnetron—					
1	24M10	24,000MC	50KW	13KV	15A
2	33M10	32,600	40	13	18
3	35M10	34,860	40	13	18
4	50M10	50,000	20	12	16

*TENTATIVE DATA

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using Circle Reader Service Card.

Hansen

(*Continued from page 14*)

an idea occured to him which did not fall into a category of his classification scheme, and he recorded his notebook, "Hansen has found that he can calculate th case of a spherical rumbatron with one core reaching the center. Such a rumbatron might make it possible make an oscillator or amplifier. If one could introdu electrons into a rumbatron . . ." When the design w presented to Dr. Hansen, it withstood the usual barrage

"Rus, maybe you've got it," Hansen said. "Let's try out and see." This, of course, was the klystron, and worked far better than they had dared hope, for it h since been credited with "a vital role in the successful a defense of Great Britain and the ultimate air superiori of the Allies during World War II."

The klystron break-through was accomplished in 19 and was a major factor in turning the big, slouch shaggy-browed Hansen toward an exhaustive study waveguides, scatter, propagation and other theoretical a practical problems in the newly-important field of micr waves. Because of this study, by the time the trouble Europe erupted into the second World War, causing rada to shoot into prominence as a vital secret weapon, Hanse was one of the country's foremost experts in the field microwaves. To take proper advantage of his knowledg and ability, Hansen was invited to join the staff of MIT famed Radiation Lab to continue his research, to teac microwave theory to selected members of the Rad La staff and to act as a consultant. He was already deepl involved in the work there by the time the U.S. entere the war.

At the same time the Varians and several others wh had been continuing the klystron project at Stanfor shifted en masse to Sperry Gyroscope on Long Islan Hansen retained his intense interest in that program, an tried to do the impossible: he worked for 16 hours on day at MIT, commuted to Sperry and put in 16 hour there the next. This schedule continued, with few interruptions, throughout the war. Few could survive suc an exhausting routine. It was to make Hansen's lif tragically short.

After the war it was a physically weakened but stil mentally vigorous Hansen who returned to Stanford t investigate the feasibility of a new application for th klystron. His plan was to use the device in the acceleration of atomic particles, in order to build an atom-smashe more powerful than the existing ones, utilizing linea rather than circular acceleration. His test models wer successful, and work was begun on a full-scale unit. Hi theoretical development of this device indicated it woul produce a billion electron volts of energy, far more tha men had ever accomplished.

As the unit was constructed it fulfilled his step-by-ste predictions precisely. Recently completed, the Mark II unit employs 30 klystrons, each with a peak power of 1 megawatts and has a beam energy of almost exactly th predicted billion electron volts. But in 1949, when con

(*Continued on page 20*)

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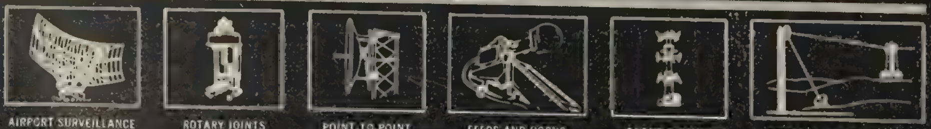
PIONEERS IN ANTRONICS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RESEARCH & DEVELOPMENT

Much has been said recently about the dissolution of our language by youngsters in their teens, members of the beat generation, angry g men, ardent followers of Method er and other imbibers of espresso. ttedly, conversation among members ese groups is difficult, if not impos- to follow. Eg:

ike let's split."

ou putting me on, man."

ike nevermore, dad. Let's fall up to ad. You got any bread?"

ool it. Like not even the butter."

ome scene."

ithout question, the culture that ibuted to the above is a somewhat used one. Yet, we at Rantec cannot oo disturbed. Frankly, it would be a calling the kettle black" type of ion if we did. Engineers too, we noticed, participate in a language of own. Now this is relatively excus- within the confines of the plant, at coffee machine or around the ping- table out in back of manufacturing. t to occur at times of more social ition is occurring, it seems to us, and more. Eg.:

How do you feel? You realize, of se, I do not mean tactilely, but in a tional sense."

You conducting a reliability study?"

Merely friendly research."

Non-tactilely, you understand, I'm ut 25 db down with an absolutely imum power level."

Shame. *I'm* right at band center. What pened?"

Little too much input last night. And, eve me, fellow scientist, the output ng isn't worth it."

This, in itself, is not too confusing cept, of course, to the poor, poor lay- n who might be present). However, we across an example the other day that ve us immediately back to the com- ting lap of the King's English. Some- v, in the course of conversation, the ne of the great firm Daniel, Mann, nson and Mendenhall came up. Three onds later, this industrial giant was erred to as DMJM which caused us to use for thought, but we eventually ght on. When a third individual, not be outdone, called this austere titan of siness DimJim, we shuddered and urned to our tiny office with a mentary vow of silence on our lips.

If you know anything about antennas, telemetry components or microwave rite components, make the scene at ntec. It's in Calabasas, California. Like where, man.

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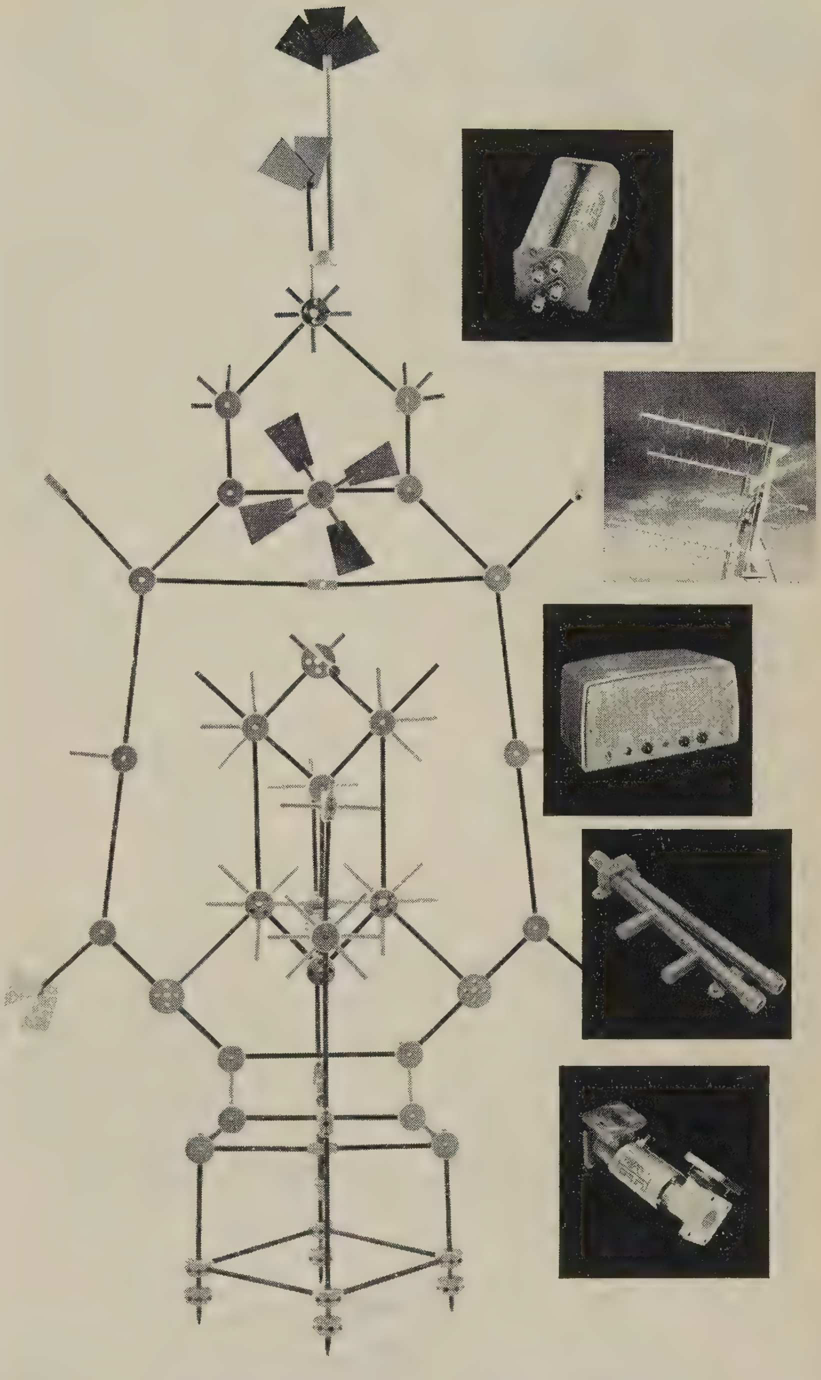

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Impedance Transformers
DC to 2000 mcs.
using type BNC, TNC, and N coaxial connectors

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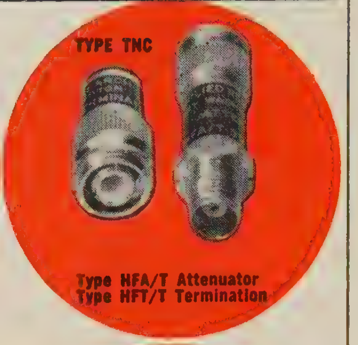
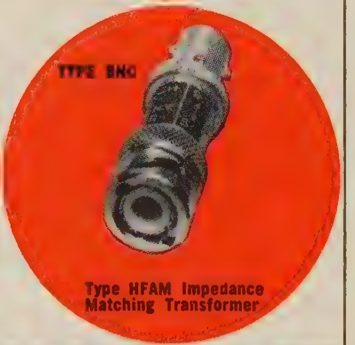
Type HFA Attenuator
Type HFT Termination



TYPE N
Type HFA/N Attenuator
Type HFT/N Termination



ARI presents an integrated line of coaxial attenuators, terminations, and impedance matching transformers for use in the DC to 2000 mcs frequency range. To provide the user with a greater flexibility than heretofore realized, type BNC, TNC, and N coaxial connectors are incorporated in this family of attenuators and terminations. The impedance matching transformers use type BNC coaxial connectors.

The attenuators and terminations exhibit a nominal impedance of either 50 or 75 ohms and a maximum V.S.W.R. of 1.2 at the highest rated frequency.

The impedance matching transformers have been designed to match, with minimum loss, 50 to 75 ohms, 50 to 93 ohms, and 75 to 95 ohms, over the frequency range of DC to 1000 mcs.

CHARACTERISTICS

	ATTENUATORS & TERMINATIONS						IMPEDANCE MATCHING TRANSFORMERS		
Model	HFA & HFT		HFA/T & HFT/T		HFA/N & HFT/N		HFAM		
Input/output impedance, ohms	50, 75	50, 75	50, 75	50, 75	50	50	50 75, 93	75 50, 93	93 50, 75
Nominal attenuation (db)	1, 2, 3, 4, 6, 10, 12, 15, 20 / 2, 3, 6, 10, 20		1, 2, 3, 4, 6, 10, 12, 15, 20 / 2, 3, 6, 10, 20		1, 2, 3, 4, 6, 10, 12, 15, 20		minimum loss		
Frequency range (mcs)	DC-1000		DC-2000		DC-2000		DC-1000		
Maximum V.S.W.R.	1.2 at 1000 mcs		1.2 at 2000 mcs		1.2 at 2000 mcs		1.2 at 1000 mcs		
Connectors	Type BNC		Type TNC		Type N		Type BNC		

For full information and prices write to

Applied Research inc.

76 SOUTH BAYLES AVENUE, PORT WASHINGTON, NEW YORK

Circle Reader Service Card 15

Hansen

(*Continued from page 16*)

struction was just being started, each day's work was struggle for Hansen. Further weakened by a pneumor attack which left him with gradually worsening bronch trouble (or perhaps, as his associates believe, it was ber liosis poisoning from his atomic research work), Hans refused the confinement of an oxygen tent ordered his doctor. Instead, he designed a portable oxygen ma and continued his work on the accelerator and as direct of the Stanford Microwave Laboratory, which the Unive sity had built for him after the war. (It has since be renamed the Hansen Laboratory, in his honor.)

Dr. William Webster Hansen died on May 23, 194 four days before his fortieth birthday.

His imposing presence, so familiar and respected his colleagues, was gone; in its place, an overpoweri void.

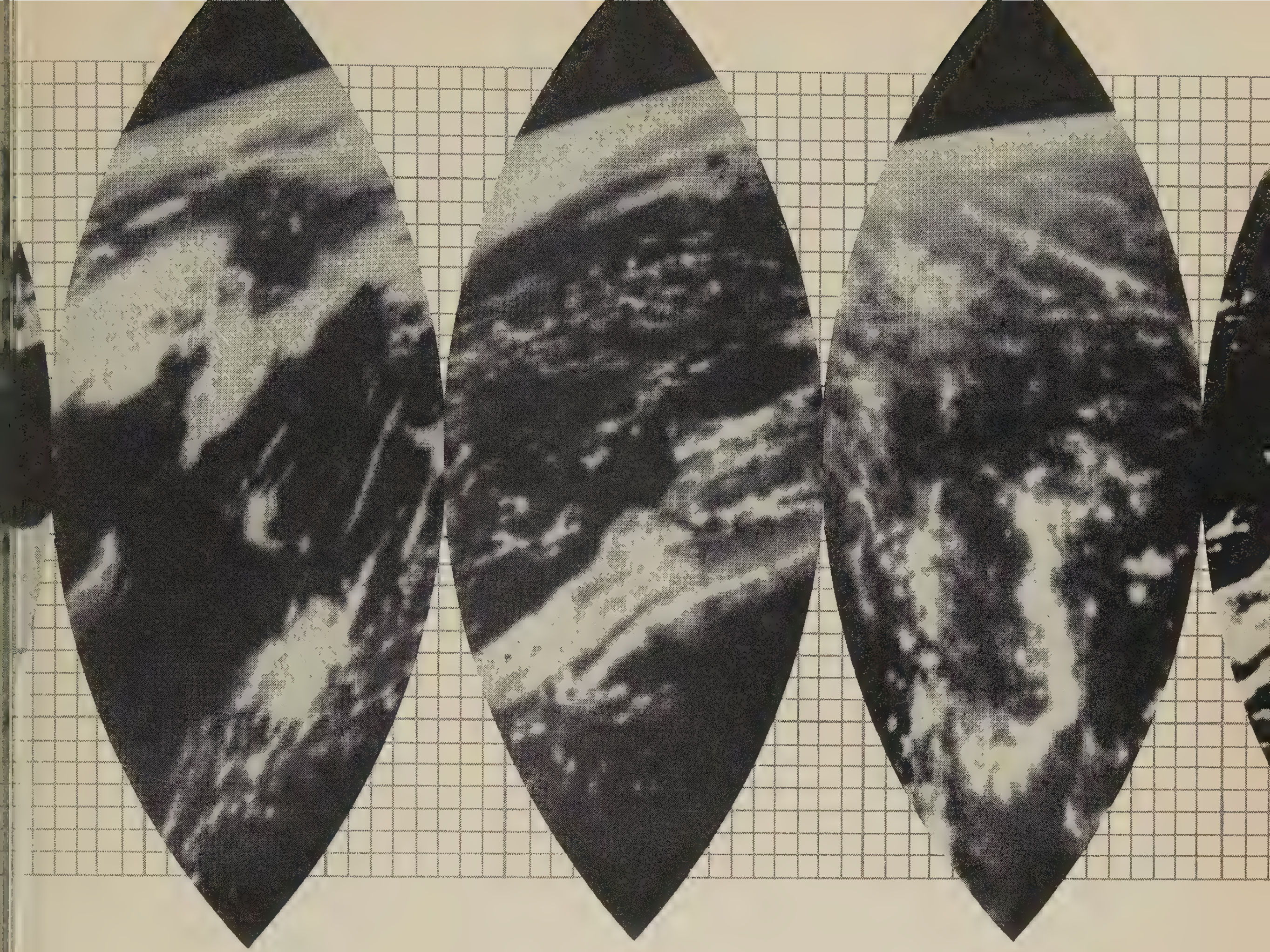
If the blow caused by his death was severe to his a sociates, it was an unbearable burden for the one close to him. In a lonely Greenwich Village apartment fo months later Betsy Ann Ross Hansen, the childho sweetheart he had married in 1938, took her own lif after writing ". . . the bottom had fallen out since t death of Bill."

His many honors and awards attest to the stature had attained in his short lifetime: the Morris Liebmar Memorial Prize in 1944; "starred" position in *Americ Men of Science* the same year; election to the Nation Academy of Sciences just before his death; a Presidenti Certificate of Merit.

A recitation of his honors doesn't tell what made hi great, but his associates knew. Frederick Terman, dean Stanford's School of Engineering, said "Dr. Hansen w one of the most fertile and original men I have know He gave great stimulation to his associates because he w filled with ideas of new things to be done and mo powerful ways of attacking old problems. Hansen credited with working out most of the microwave tech niques used during the war. He was a rare combinatio almost unique, of a theoretical physicist and a thorough practical engineer. He was noted among scientists b cause his ideas always worked. He had a great gift f new ideas plus the ability to sift them through and pic out the good ones. Then, through his understanding machine tools, he could go into the laboratory or machin shop and make his ideas work."

And Stanford physics professor David L. Webster (th same man who had helped Hansen return to Stanfor from Fresno), said, "His unbounded energy and enthu siasm were a great inspiration to all his students an associates in research. It was his devotion to duty in th war, his willingness to go ahead, regardless of risk, tha brought on the illness which has now proved fatal. S even though he was not in uniform, he deserves all hono as a brave soldier."

This was William Webster Hansen: an Uncommo Man.



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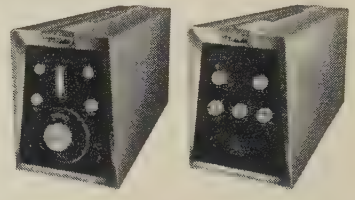

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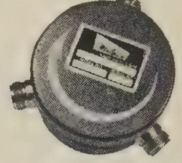
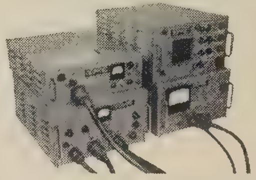


Model X-127 400 MC Circulator, compact three-port instrument with a 10% bandwidth at 400 MC.



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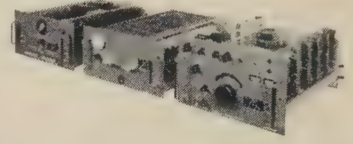

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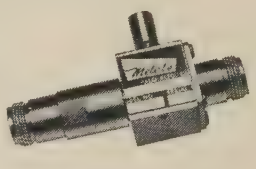

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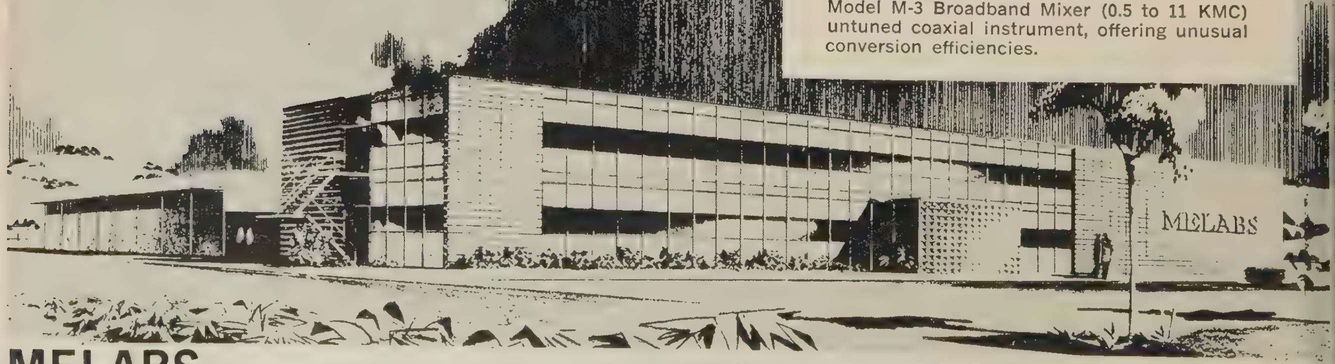

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LEADERSHIP IN SCIENCE

BENJAMIN LAX,* ASSOCIATE EDITOR, *the microwave journal*

lato, in his conception of the ideal state, evolved a me for choosing and training its rulers. His program training its military leaders and ministers in a modi- form was adopted quite successfully by the Turkish oman Empire during the two centuries of its golden To this end the Turks selected and educated the most nted boys within their empire regardless of race or gious origin, some of whom were enslaved Christians. some respects the Russians in their own stilted ion are imitating this technique not only for political military leadership, but also for training and choosing r elite in the field of science. The incentives and the rds for accomplishments in science and engineering the most talented in a privileged class in their society. type of favorite treatment encourages a greater per- age of their brilliant students, both men and women, eek a career in science.

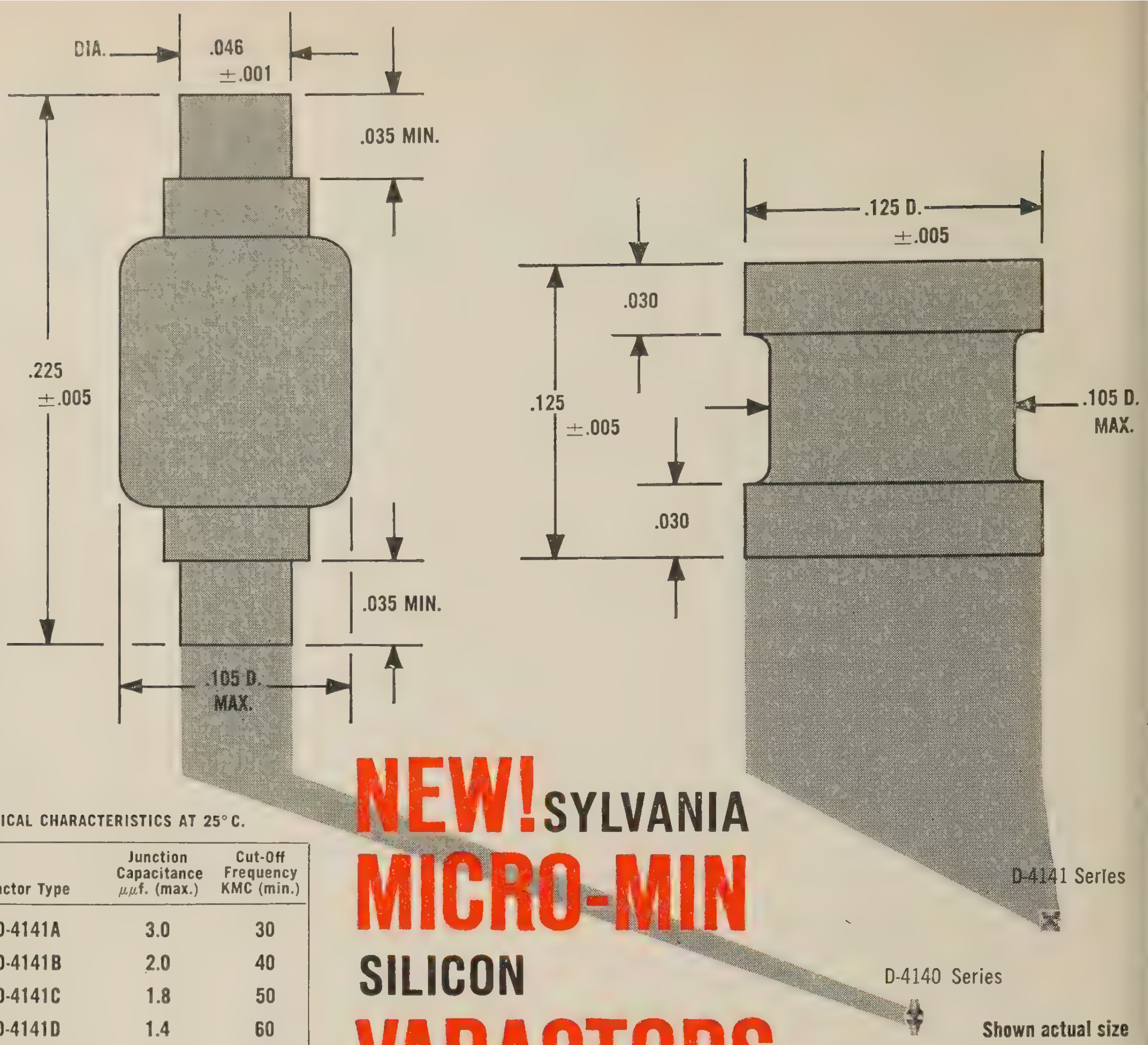
or outstanding people in our society, the financial re- ds and the prestige are often greater in business, ertising, top industrial positions and in independent fession careers. This in itself would be a desirable l if the world were really at peace. However, today n science and technology permeate every facet of our s, there is a critical need for leadership in science, icularly in the academic and military areas. The cold which exists between the West and the Communists not only fought on a political and economic front, but on a technological one which is strongly coupled to other two. If we are to succeed and maintain our over- scientific lead, which we possess today, we must ognize some hard realistics in this context. With an r expanding technological national program, the need qualified people in science and engineering will be- ne increasingly critical. But above all, the necessity of viding proper leadership for this great army of engi- rs and technicians of the future will be even more portant. Among the groups competing for this top nt which includes military establishments, government ncies, private foundations, universities and industrial oratories, the lion's share of the limited supply under present circumstances will probably go to industry. we examine this very closely, we will find that this can ve serious consequences for the future. If we do not rease the number of capable candidates for responsible sitions in our institutions and apportion them properly among each of them, we will inevitably kill the goose that laid the golden egg.

It might be interesting to review some of the facts that have lead to the present dilemma. This problem which actually started in World War II was solved by a very drastic method which can only be possible under such emergencies. In order to meet our dire and urgent needs at the outset of hostilities, we were able to recruit all our scientific talent from universities and industries, together with those in government laboratories and even many technically trained people in uniform to do research for military ends. We had complete mobilization of trained people to invent, develop and build radar, sonar, modern weapons and the atom bomb. We evolved the highly successful team research technique built around very capable and imaginative scientific leaders. After the war these teams were dissolved and we again mobilized just as effectively for peace. We organized teams to produce radios, TV's, refrigerators, automobiles and all the hardware for civilian life. Some of the scientists returned to the universities; some joined the new larger government laboratories; many also went to industry; and the younger men went back to study to obtain advanced degrees.

Things appeared to be returning to normal. We had a recession, cutback in military spending and in some government laboratories. We were even worrying about the overabundance of engineers when the cold war began to turn hot in Korea. From then on government spending for hardware and applied research grew yearly. Electronic firms grew overnight, industrial and government laboratories expanded and new ones were created. Salaries for scientists grew with industry setting the pace. Graduates with engineering and physics degrees became the darlings of recruiters and were wooed and dined by their potential employers. Many scientists in universities left their professional ranks for greener pastures. Government laboratories lost many of their leading scientists who could command greater salaries and better opportunities in private enterprise. Some of the mature and established scientists from universities took indefinite and intermittent leaves from their pedagogical and research duties to join committees, study groups and to accept responsibilities in high government posts. Young researchers who had just begun to make their marks formed their own companies and became budding entrepreneurs. Others before their time became administrators. Military men together with some

(*Continued on page 26*)

Head, Solid State Division, Lincoln Laboratory, a center for esearch operated by Massachusetts Institute of Technology with he joint support of the U.S. Army, Navy and Air Force.



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D-4140C	D-4141C	1.8	50
D-4140D	D-4141D	1.4	60
D-4140E	D-4141E	1.0	70

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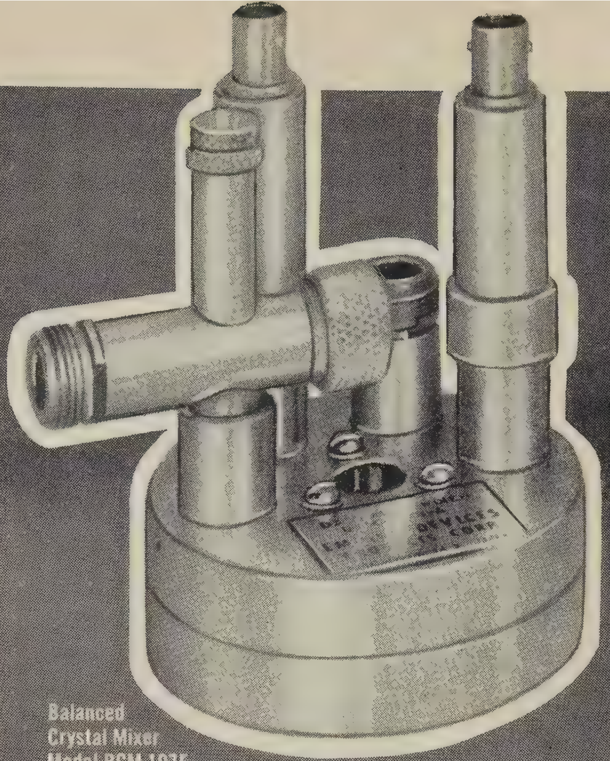
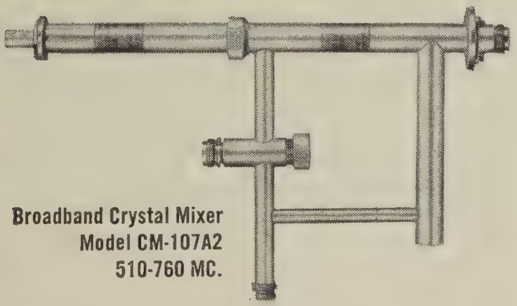


Balanced
Crystal Mixer
Model BCM-107E
2500-2900 MC.

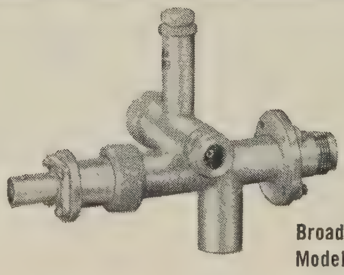
BALANCED MIXERS, Model BCM-107

For R.F. frequencies from 1000 to 5600 MC.
Models for push-pull or single-ended I.F. inputs.
Featuring, over a 15% bandwidth:

★ Input VSWR less than 1.5 to 1, without adjustment.
★ L.O. noise cancellation at least 20 DB.
★ Isolation between R.F. and L.O. at least 20 DB.
★ L.O. rejection at I.F. terminals at least 30 DB.



Broadband Crystal Mixer
Model CM-107A2
510-760 MC.



Broadband Crystal Mixer
Model CM-107F
4000-5600 MC.

BROADBAND MIXERS, Model CM-107

For R.F. frequencies from 225 MC to 8200 MC.
Featuring over a broad range of frequencies:

★ Input VSWR less than 2 to 1, without adjustment.
★ L.O. VSWR less than 2 to 1, without adjustment.
★ L.O. rejection at I.F. output, better than 30 DB.
★ L.O. power requirements 10 MW, with adjustable injection feature.

For complete data, send for Catalog 604.

edp

EMPIRE DEVICES PRODUCTS CORP.
AMSTERDAM, NEW YORK
VICTOR 2-8400

MANUFACTURERS OF:
FIELD INTENSITY METERS • DISTORTION ANALYZERS • IMPULSE GENERATORS • COAXIAL ATTENUATORS • CRYSTAL MIXERS

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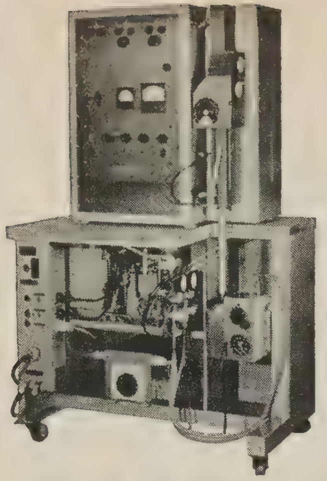


UNIQUE
VERSATILE
COMPLETE
microwave
dielectrometer

Measures dielectric constant and loss over a wide temperature range at 1, 3, and 8.5 kmc.

With a complete line of accessories the Central Research Laboratories Dielectrometer gives high accuracy and unequalled versatility.

Accessories now available: *Temperature Control Unit.* Enables dielectric properties of solids to be measured at any temperature between −30°C and +500°C; liquid samples to +150°C. Includes waveguide extension and sample holders for solids and liquids.

Room-Temperature Extension Sample-Holder. For measuring liquids or semi-solids at room temperature only.

Quarter-Wave Spacers. Accurately-cut, low-loss quarter wave spacers to make open-circuited measurements or gain greater sensitivity with thin samples.

For brochure giving details and specifications, write:

Central Research
laboratories, inc.
Dept. 203 — Red Wing, Minnesota

Circle Reader Service Card 19

Lax

(*Continued from page 23*)

civilian assistants became managers and planners of largest patronage of scientific research in history.

To top this off, conferences sponsored by professio societies and other groups within and without laborator became more frequent. We spend more time talking a writing about less, or at least more often about the sa things. Visits by sponsors, brain-pickers and sometin curious competitors have become the fashion. In additi the loss of creative and productive activity due to phenomenal turnover spurred by highly competitive b ding for established engineers and physicists certainly ac to the loss of manpower. Who is keeping the store? W is doing the research, the training of the next generati of scientists?

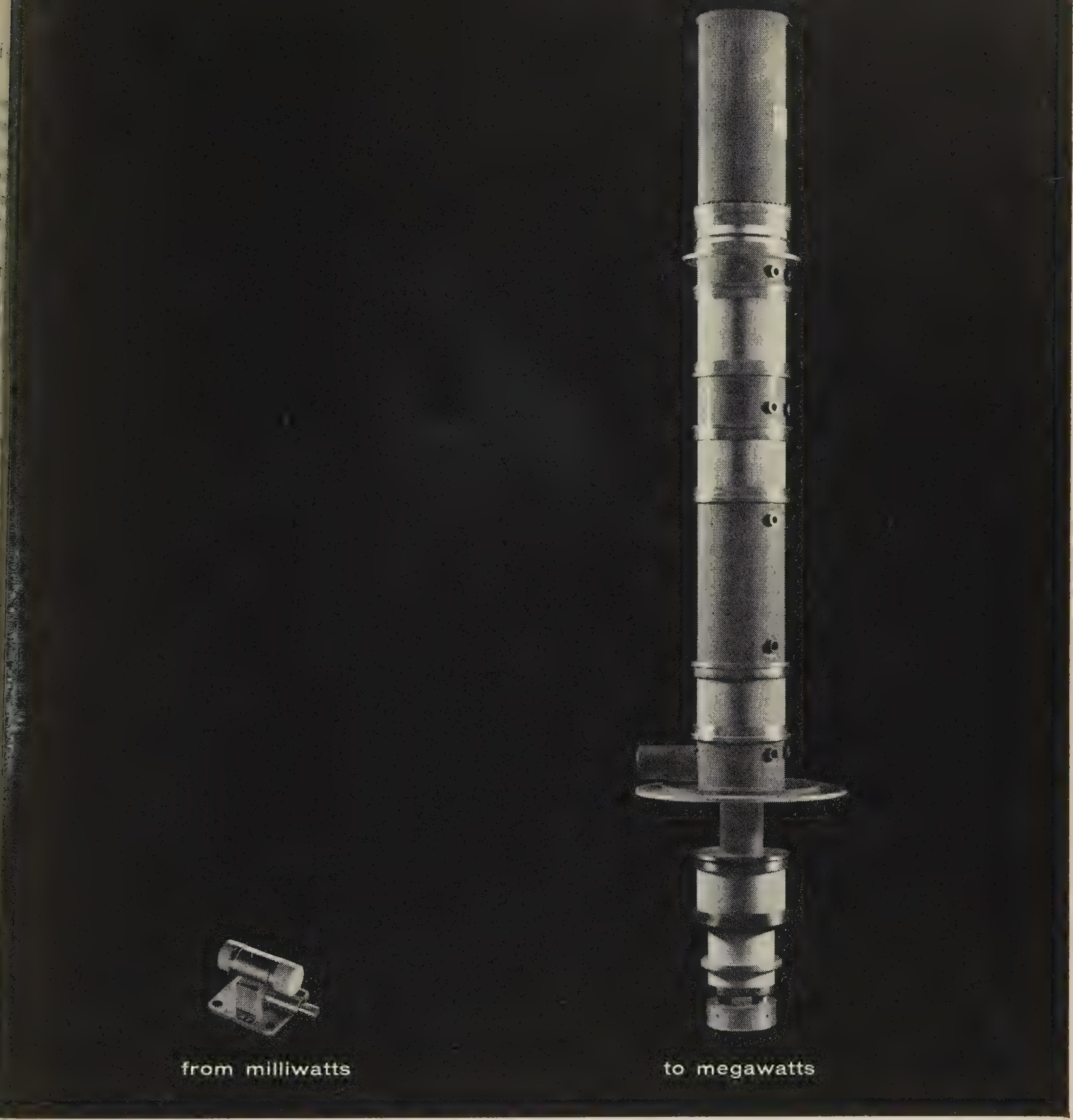
The situation as it exists today is that there are n enough first-rate people to do all the tasks required scientists today, especially under the conditions outlin above. We do not have enough competent science teach in schools and universities to train and attract our youn sters into the field. There is also a shortage of those ra individuals who may be classified as great teachers, w can inspire the gifted students, inculcate in them t philosophy and proper spirit of science so that they m not forsake their true calling for economic advantages.

Government laboratories need top-notch people ju as well as industry and universities. They have tremendo responsibilities in leading and administrating large scie tific programs. There are a few dedicated people w stay in Civil Service, but for the most part this is not tru The identical type of responsibility pays considerably mo in industry — why not in government? The salary of tv mediocre men equals that of one outstanding one. T performance of the latter is worth more than twice th of the former. Often mediocre people cannot do the j at all — in fact, they may bungle it. From a practic point of view this is false economy.

In the military, the leadership problem in science h different aspects. The military people are in general t users of the products of science. Nevertheless, as one of t largest customers and sponsors of science, they mu exercise critical technical judgment. Superficial knowledg and a speaking acquaintance is not enough. Research a ministration requires highly technical background an long years of experience in a particular area of endeavo Constant rotation and change of assignment which shi fields is often undesirable. A man who has spent his li as a combat officer cannot be expected to administer research and development command. Private organizatio whether industrial or academic choose their leaders fro those who have risen within their ranks as engineers educators. Why not have military men at high and inte mediate rank who are specialists in science and its ad ministration?

Leadership of science in industry has its problems als In large companies where research is on a grander scal the particular danger is that administrative positions ar made more attractive for the well-rounded individu whereas creative positions which are just as importan particularly for the gifted ones, are not on an equal foo ing. In small companies the talented man becomes jack-of-all-trades, or as I mentioned before, an entrepre

(*Continued on page 28*)



EIMAC OFFERS RF POWER FOR ALL AIR-SPACE SYSTEMS

From miniature microwave devices to the highest power klystron, Eimac offers rf power for every type of air-space system. With tubes designed for airborne communication. For warning systems. For tracking and guidance. You can look to Eimac as the one source of all your rf power needs. ■ For still further progress, new tube types to meet new needs, Eimac continues to forge ahead with the most advanced research facilities available today for power tube development. And its manufacturing program is unmatched in ability to turn blueprint ideas into quantity production. No wonder Eimac tubes power nearly every major air-space system the world over: telemetry, troposcatter, navigational radar, high-power radar—including the recent BMEWS program. Eitel-McCullough, Inc., San Carlos, Calif.

Eimac

Circle Reader Service Card 20

(*Continued from page 26*)

neur, so that his effectiveness as a scientist or as a leader of a team of scientists diminishes.

The problem of providing qualified and adequate numbers of leaders for our growing technology is a complex one. The first problem is to train and educate a sufficiently large number of really capable people. We can do this in many ways. Scholarships at undergraduate and graduate level on a proper scale, on a competitive basis can be most helpful. The G. I. bill of rights, which did not discriminate in favor of the good student, nevertheless was responsible for training many of the scientists who are playing an important part in our affairs today. Why not a peacetime equivalent of this for the best of our youngsters? We train our military men at a good level of support in our military academies. The cold front today is in science also. It is logical then that our government should subsidize our future scientific leaders as it does military personnel. This subsidy should be open to women as well as men. Women today are a great potential in science. If enough intelligent girls enter the field of science, we can increase our "manpower" substantially.

The next major problem is to attract more good people into the teaching profession at all levels. This can be done by increasing salaries not necessarily to the industrial scale, but somewhat below. Some of the leading universities have done just this with some success. The problem at the high school level is certainly more difficult. Perhaps the answer to this is the establishment of scientific chairs in appropriately selected high schools, simi to those in universities. The prestige and the salary co mensurate with the position may attract outstand teachers. The Ford Foundation and others might w support these, and communities themselves could establ them in science and other fields also.

Assuming that we can educate more of our able peo in science, the question of distributing them prope among the various organizations of our society still mains. The present dog-eat-dog competition for them v not permit this, since it favors one group. If governm subsidization of students is adopted similar to that of military academies it can require service in one of many agencies in return. This certainly can help so For the military the answer is more obvious. They train scientific officers in the same way they train com officers. To a limited extent this has been done in in vidual cases.

The above problem can be discussed endlessly. T author does not lay unique claim to it. Many more co petent authorities have written about this topic. Perha the objective that has been achieved here is an attempt a more provoking and unconventional approach. T solutions offered may not be the most appropriate, they indicate the existence of the problems and so possible directions toward their solution. Fortunate there is an awakening to these problems nationally, a some things are being done. The burning question: is enough? ? ? Dr. Edward Teller and Admiral Rickover not seem to think so. The author is inclined to agree wi them.

Temperature Compensated
COAXIAL ISOLATORS

Available . . . two new temperature compensated coaxial isolators for difficult operating environments. Optimum performance over a very wide temperature range is achieved through use of a temperature sensitive shunt. Specifications for each unit (Model N-100-D shown above) are:

	Model N-100-D	Model NS-101-B
Frequency	1.25—1.365 kmc	2.9—3.6 kmc
Isolation	25 db min.	20 db min.
Insertion Loss	1.4 db max.	1.0 db max.
VSWR	1.20 max.	1.25 max.
Avge. Power Rating	1 watt	10 watts
Peak Power	1 kw	10 kw
Fittings	Type "N"	Type "N"
Length	10¼ inches	8.22 inches
Price	$375.00	$375.00

Both are furnished in attractive dark green, baked enamel finish. Mating surfaces are silver plated by a process which minimizes tarnishing. Units are ruggedized, have four holes for mounting.

Write for specifications and price list of complete series of Caswell isolators

CASWELL
ELECTRONICS
CORPORATION
414 Queens Lane, San Jose, California

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SOLID STATE *Research*

PRECISION FERRITES

can help you solve your design problem, as it did for one of our customers.

PROBLEM: Design an X-band isolator with an insertion loss of less than 0.3 db and an isolation of at least 17 db. The isolator must be smaller than any commercially available and operate at 300 kw peak power.

SOLUTION: NF-11A with its high g 4 m_s product of 4100 requires lower magnetic field for resonance than other materials and hence the size reduction was possible.

NF-11A is an extremely linear nickel ferrite and operates excellently at the power level specified.

Mr. Designer: Let our engineering staff suggest a precision ferrite for your application. Write:

**Solid State Research
Inc.**
15207 Stagg Street
Van Nuys, Calif.

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LEADS THE INDUSTRY IN ULTRA-HIGH-POWER DUPLEXING

with both GAS DISCHARGE and FERRITE DUPLEXERS

Selecting a duplexer for high-power applications involves consideration of peak power, average power, transmit loss, receive loss, expected life, and versatility of operation.

All Microwave Associates high power gas duplexers utilize special window structures for optimum switching efficiency without sacrifice in low-level loss characteristics. These windows insure reliable, long-life performance. Both our gas and ferrite duplexers may be operated over very broad bandwidths at the common microwave frequencies.

Exceptionally complete ultra-high-power design and test equipment is utilized by our Research and Production Departments. Each duplexer is fully tested at maximum rated power before shipment.

We have extensive experience in designing and manufacturing high-power duplexer devices and are interested in working on newest ultra-high-power applications. We are now developing ultra-high-power duplexers for more efficient switching at UHF, L, C, and S bands.

Our Applications Engineers would like to discuss the future of high power duplexing with you.

equency Band	Duplexer Type	Peak Power	Average Power	Transmit Loss (max.)	*Receive Loss (max.)	Bandwidth
UHF	Gas	5 Mw	300 Kw	0.1 db	0.4 db	Tunable
	Gas	25 Mw	75 Kw	0.1 db	0.4 db	10% Nominal
L	Gas	25 Mw	50 Kw	0.1 db	0.5 db	
S	Gas	6 Mw	30 Kw	0.1 db	0.7 db	
	Ferrite	3 Mw	5 Kw	0.5 db	0.9 db	
C	Gas	5 Mw	5 Kw	0.1 db	0.7 db	
	Ferrite	5 Mw	7.5 Kw	0.3 db	0.8 db	
X	Gas	500 Kw	500 W	0.2 db	1.0 db	
	Ferrite	1 Mw	1 Kw	0.3 db	0.9 db	
Ku	Gas	150 Kw	150 W	0.2 db	1.0 db	
	Ferrite	150 Kw	150 W	0.3 db	0.9 db	
Ka	Ferrite	75 Kw	75 W	0.3 db	1.1 db	4% Nominal

All Microwave Associates duplexers incorporate low-loss, long-life, receiver protectors which guarantee crystal protection over wide temperature ranges and under extreme environmental conditions.

e duplexer receiver loss includes the loss due to receiver protector TR tubes.

At each frequency band of the microwave spectrum, Microwave Associates has devices for efficient switching of high power.

MICROWAVE ASSOCIATES, INC.

BURLINGTON, MASSACHUSETTS

Western Union FAX-TWX: Burlington, Mass., 942 • BRowning 2-3000

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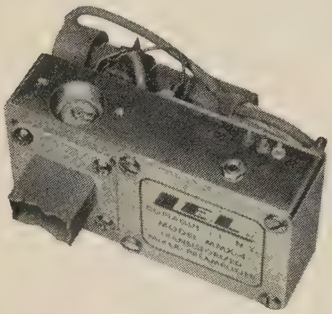
LOW NOISE

for C Band

The MMC Series of Integrated Waveguide Mixer-Preamplifiers.

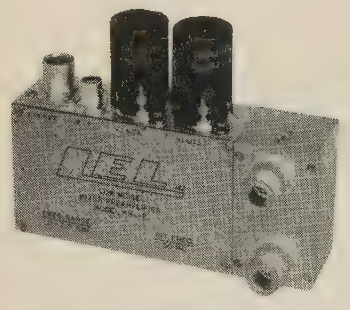
Noise Figure: 7.5db



for X Band

The MMX Series of Integrated Microwave Mixer-Preamplifiers.

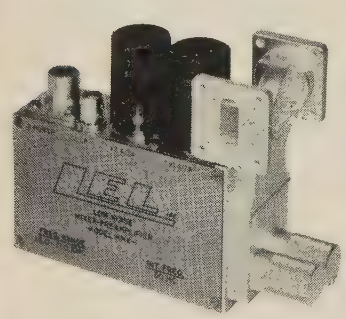
Noise Figure: 7.5db



for L, S and C Bands

The MML, MMS and MMC Series of Coaxial Mixer-Preamplifiers.

Noise Figure: 7.5db



for KA and KU Bands

The MMK Series of Integrated Microwave Mixer-Preamplifiers.

Noise Figure: 10.0db

LEL stocks the most complete line of low noise microwave Mixer-Preamplifiers available ANYWHERE.

Write for a comprehensive Microwave, IF, RF Amplifier Catalog.

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AMityville 4-2200

Industry News

McCULLOUGH APPOINTED DIRECTOR OF MARKETIN AT LITTON INDUSTRIES

John S. McCullough, has been appointed director of mark ing for Litton Industries Electron Tube Division, San Carl Cal., developer and manufacturer of microwave tubes and display devices.

In making the announcement of the newly-created department, Dr. Norman H. Moore, vice-president of Litton and general manager of the tube division, said the move is a result of "new marketing areas in the electronics field and the increasing role the Litton electron tubes are playing in new commercial and government systems."

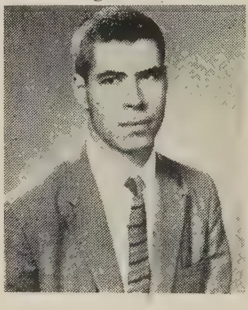
McCullough, who heads up a staff group responsible marketing services and sales coordination, has been associa with the Electron Tube Division since 1959 as assistant to general manager in charge of new product planning. Prior joining Litton, he was director of research and engineering Eitel-McCullough, Inc., San Carlos, Cal., where he was ployed for 13 years.

McCullough attended the University of California, Harv University, and Massachusetts Institute of Technology. has been active in the Institute of Radio Engineers, West Electronic Manufacturers' Association and the Western E tronic Convention.

—*mwj*—

DAVIS NAMED MICROWAVE CHIEF ENGINEER AT MOTOROLA

Motorola Inc., Chicago, Ill., has named Robert H. Davis Chief Engineer of its Microwave Department. In this capac he is responsible for microwave p duct development, systems engine ing and field engineering.



Davis has been associated with Microwave Department since gra ating from the University of Min sota in 1950. He served as a fi project engineer for four years, th was appointed manager of microw systems engineering in 1954. In 1 he assumed additional responsibilit of microwave publications.

—*mwj*—

STARK NAMED TO MICROWAVE POST AT HUGHI PLANT

Louis Stark has been named assistant manager of the ra laboratory's microwave department at Hughes Aircraft C ground systems group, Fullerton, Cal., according to Nicholas A. Begovich, assistant group manager.

Stark, who rejoined Hughes last year after previously wo ing for the company from 1954 to 1957, reports to Nicholas Yaru, acting microwave department manager associate radar laboratory manager.

Stark served as an assistant group leader in microw components at Massachusetts Institute of Technology's L coln Laboratory from 1957 to 1959.

—*mwj*—

MELPAR TUITION PAYMENTS TOTAL $79,000

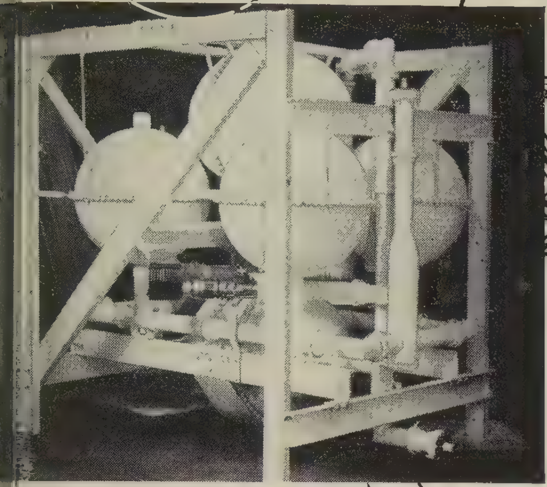
Melpar, Inc., Falls Church, Va., has paid out $79,395.19 education grants to its employees since establishment of company's Tuition Reimbursement Plan nearly four years a Melpar President Thomas Meloy announced that 342 ployees received reimbursements of $14,140.51 between Ma 1 and August 1, 1960, for courses completed.

Melpar pays half the tuition and laboratory fees on approved scientific and technical courses successfully c pleted by its employees.

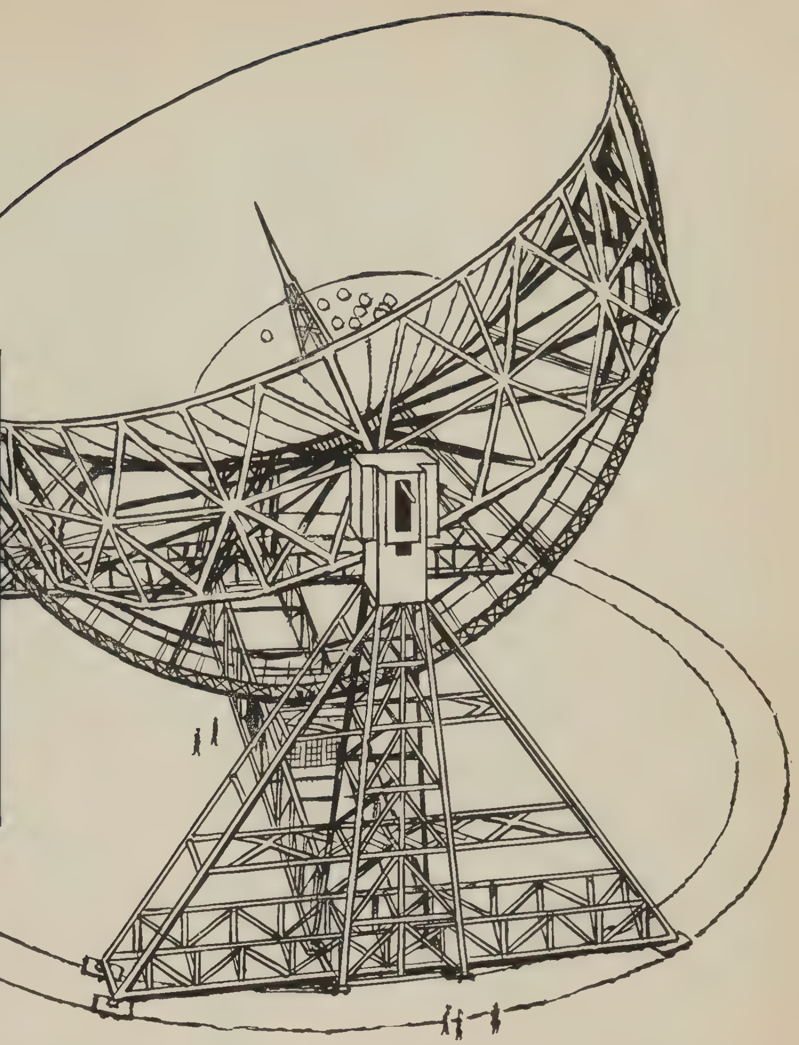
—*mwj*—

(*Continued on page 32*)

ANOTHER MEASURE OF DIELECTRIC'S CAPABILITY



THIS UHF DIPLEXER NETWORK
s built by **DIELECTRIC** Products
gineering Company, Inc., under
ontract from Space Technology
oratories, Inc. It is now installed
in the tower of the single giant
ntenna of "SpaN Net's" Jodrell
radio telescope at Manchester,
England. Its function is



lating simultaneous signals to and from deep-space payloads

Commanding and monitoring space vehicles is the responsibility of "SpaN Net" . . . a global network of radio telescopes set up and operated by Space Technology Laboratories for U.S.A.F.

To fulfill its mission, "SpaN Net" had to meet challenges far beyond the state of the communications art. Never before had powerful command signals and faint telemetered deep-space data been simultaneously handled by a single antenna. How could transmit and receive channels with a differential of more than 200 decibels be isolated? Conventional diplexer technology was not the answer.

Teamwork solved the isolation problem! "SpaN Net" assigned the task to Space Technology Laboratories, Inc., who added DIELECTRIC of Maine to its research, development and production team. Result? An ultra-high-frequency diplexer network that allows the Jodrell Bank radio telescope's single antenna to transmit 20 kw commands and receive 0.002 microvolt signals . . . simultaneously.

This contribution to SpaN Net's break-through is typical of product advances by DIELECTRIC. If you have similar problems in communications . . . from design to delivery . . . it pays to contact DIELECTRIC. Capabilities, facilities and accomplishments are described in our brochure. Write for it today.

Other areas of **DIELECTRIC** capability in coaxial, waveguide and open wire techniques . .

TRANSMISSION LINE & COMPONENTS • NETWORKS • SWITCHES • ANTENNAS & FEEDS
TEST EQUIPMENT • R&D ENGINEERING

DIELECTRIC
for solutions to
communications
problems.

DIELECTRIC PRODUCTS ENGINEERING CO., INC.

RAYMOND, MAINE

Circle Reader Service Card 25

A ROTARY JOINT THAT'S NEVER BEEN IMPROVED UPON… BUT WE, AT CANOGA, TRY

GETTING ENERGY "AROUND THE CORNER" HAS BEEN AN ENDURING PROBLEM FOR THE MICROWAVE ENGINEER DEALING WITH WAVEGUIDE. THE ROTARY JOINT, STANDARD EQUIPMENT ON HOMO-SAPIENS SINCE THE FIRST MODEL WAS TURNED OUT AT THE EDEN PLANT, IS THE OBVIOUS—IF DIFFICULT TO ATTAIN—ANSWER. CANOGA ROTARY JOINTS—IN-LINE AND RIGHT-ANGLE—PROVIDE, THROUGH THEIR UNIQUE DESIGN, AMAZING FLEXIBILITY FOR RADAR SYSTEMS AND ANTENNA MECHANISMS. IN BETWEEN ELBOW BENDING, WRITE CANOGA FOR COMPLETE SPECIFICATIONS.

PRESSURIZED MODELS AVAILABLE — ALL BANDS THROUGH Ku — HIGH POWER — HIGH SPEED

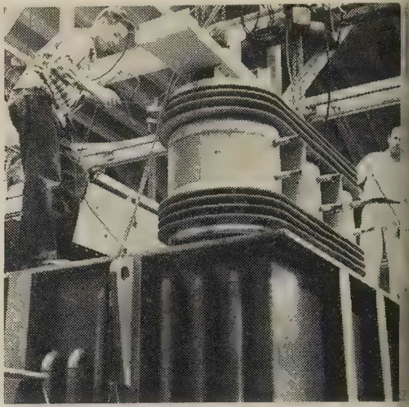
canoga

CANOGA CORPORATION/A SUBSIDIARY OF UNDERWOOD, VAN NUYS, CALIF. AND FT. WALTON BEACH, FLA.

Circle Reader Service Card 26

(*Continued from page 30*)

ELECTRO ENGINEERING WORK ANNOUNCES DEVELOPMENT O GIANT POWER SUPPLY



Successful completion of the develo ment and construction of one of t largest high voltage — high curre power supplies ever built, was announc recently by W. W. Wahlgren, preside of Electro Engineering Works, S Leandro, Cal., when his firm delivered Levinthal Electronic Products, Inc. a 27 000 volt 1 ampere dc transformer for t missile-tracking radar system of the Nik Zeus program.

The power supply, packaged in tw tanks that weigh more than 75 tons a insulated in 12,000 gallons of oil, w be used for processing and testing sup power klystron tubes. According to D Elliott C. Levinthal, president of Levi thal Electronic Products, Inc., Palo Alt Cal., it is an important part of a syste that will be delivered in the near futu to the Sperry Gyroscope Co., Gre Neck, N.Y.

The two tanks that house the tran former-rectifier assembly are both feet high and 10 feet wide. Howeve the larger tank is 18 feet in depth an weighs 50 tons; while the smaller tan is 10 feet deep, weighing approximate 25 tons.

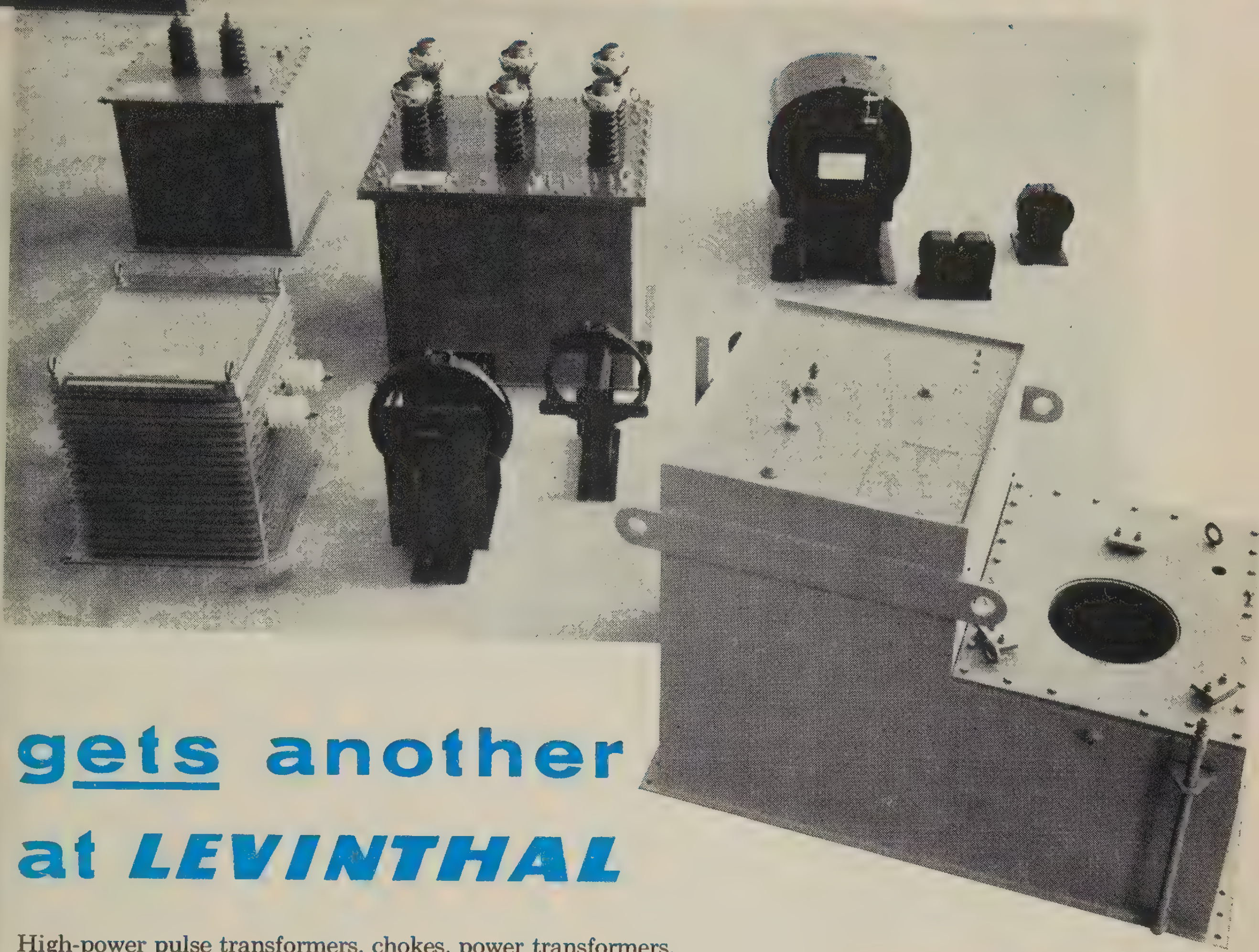
The power output is approximate 300 kw. In order to achieve this hig output and stay reliably within t capabilities of high voltage rectifi tubes, three stages of 100 kv power su plies are "cascaded" in the system. T first tank contains the first two stage The second tank contains the third stag plus filter inductor, klystron filame transformer and modulating anode bi transformer — all insulated for the fu output voltage.

Wahlgren explained that Electro E gineering Works has long specialized high voltage transformers and power su plies for advanced electronic application This particular project, he stated, is n only the largest ever undertaken by h firm, but represents the largest hig voltage-high current power supply bu in the West — and possibly the large ever built anywhere.

(*Continued on page 34*)

Circle Reader Service Card 27

one good tur



gets another at *LEVINTHAL*

High-power pulse transformers, chokes, power transformers, and related magnetic components roll out of the Levinthal transformer department in a daily stream.

The advanced and expanding facility for producing these specialized high-quality devices is limited physically only by the present bake-out oven which is 4½ by 9 by 6 feet. As far as we can discover, there is *no* limitation on the engineering skills of the staff.

They are prepared to undertake projects in the following general categories: Pulse transformers to 600 kv with average powers of several-hundred kva, peak powers to 100 megawatts, and pulse lengths to 500 μsec; Power transformers separately or in assemblies to commercial or MIL specifications over the range 10 to 55 kv d-c and 1 to 400 kva; Filter reactors in commensurate ranges; and High-voltage low-capacitance and/or high-reactance dry-type isolation transformers from 10 to 55 kv and with outputs from 100 v-a to 6 kva.

PULSE-TRANSFORMER ASSEMBLY

Above, complex pulse package for beam-type tube, to MIL-T-27A specification. Comprises main pulse transformer, low-capacitance filament transformer, filament-current transformer, beam peak-current transformer, secondary capacitance divider, tube socket, and focus-coil mount. Ratings: 132 kv at 98 amp peak; 11 μsec at 191 pps; 3.25 μsec at 381 pps.

RECTIFIER PLATE TRANSFORMER

Center, suitable for use with various rectifiers, unit supplies 45-kv d-c, with reversible polarity, at 0.15 amp. Includes: 3-phase delta to wye rectifier transformer and 6 rectifier filament transformers.

COMPACT CHARGING REACTOR

Far left, concentrating three times the power capability of the commercial unit, behind it, into a 17-in. cube, this MIL-spec choke has Class H construction and finned case for 180 C operation. Ratings: 3.45 hy, 22.5 kv peak, 3.40 amp, 190 pps.

MISCELLANY

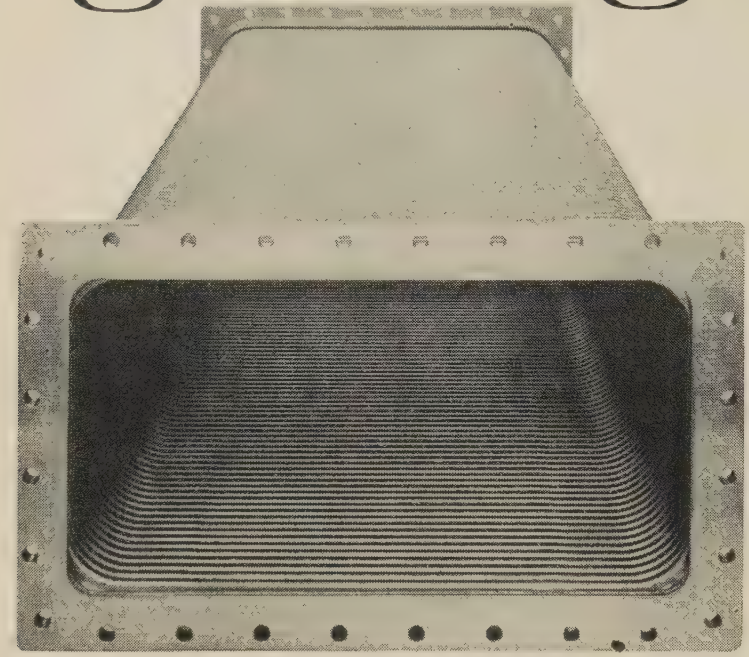
Other units shown include 40- and 50-kv low-capacitance filament or isolation transformers from a standard line and miscellaneous low-voltage filter chokes.

SMITTERS, MODULATORS, AND POWER SUPPLIES FOR COMMUNICATION, RADAR, AND TUBE DEVELOPMENT

LEVINTHAL ELECTRONIC PRODUCTS
STANFORD INDUSTRIAL PARK · PALO ALTO 7, CALIFORNIA

SUBSIDIARY OF
RADIATION
INCORPORATED

guiding


APPROX. 1/6 SCALE

light

WITH A CROSS SECTION OF 10½ BY 21 INCHES, this is the largest and lightest-weight waveguide ever made. The all-aluminum construction significantly reduces weight, as well as the possibility of corrosion. Other important advantages: high temperature applications up to 700° F.—low VSWR and attenuation characteristics—and the ability to handle extremely high power (designed for several hundred KW of average power and over a hundred megawatts of peak power). Airtron aluminum flexible waveguides are available in a number of sizes from WR-90 to WR-2100. Write for additional facts.

AIRTRON
A DIVISION OF LITTON INDUSTRIES

AIRTRON-LINDEN • 1301 EAST LINDEN AVENUE, LINDEN, NEW JERSEY
GENERAL OFFICES, MORRIS PLAINS, NEW JERSEY

Circle Reader Service Card 28

Industry News

(Continued from page 32)

PARAMETRIC MODE TRANSISTO HITS MICROWAVE RANGE

The semiconductor division of Hugl
Aircraft Co., Culver City, Cal., is bui
ing a laboratory production line for
parametric mode transistor that opera
at ultra-high and microwave freque
ranges in the circuit recently invent
and demonstrated at Lenkurt Elect
Co., Inc., a subsidiary of General Te
phone & Electronics.

The Hughes transistor is the first e
designed to operate in the paramet
mode at a frequency range two to f
times higher than what was consider
the absolute frequency limit of any co
mercial transistor.

It has produced nearly four kmc
10 per cent efficiency when tested
the UHF and microwave mixer-oscilla
circuit invented last fall by Dr. Vladin
W. Vodicka of Lenkurt's Advanced D
velopment group. The transistor's d
signer, Hughes' physicist Rainier Zule
predicts even higher frequency ranges
the microwave region—eventually
to 10 kmc while still retaining a mi
mum efficiency of 10 per cent.

The Vodicka circuit extends the p
formance of transistors so that they d
velop useful gain considerably beyo
their normal cutoff frequency. At t
same time, it reduces the inherent no
of transistors to an extremely low lev

—*mwj*—

SWISS CHEMIST NAMED TO VARIAN SUBSIDIARY STAFF

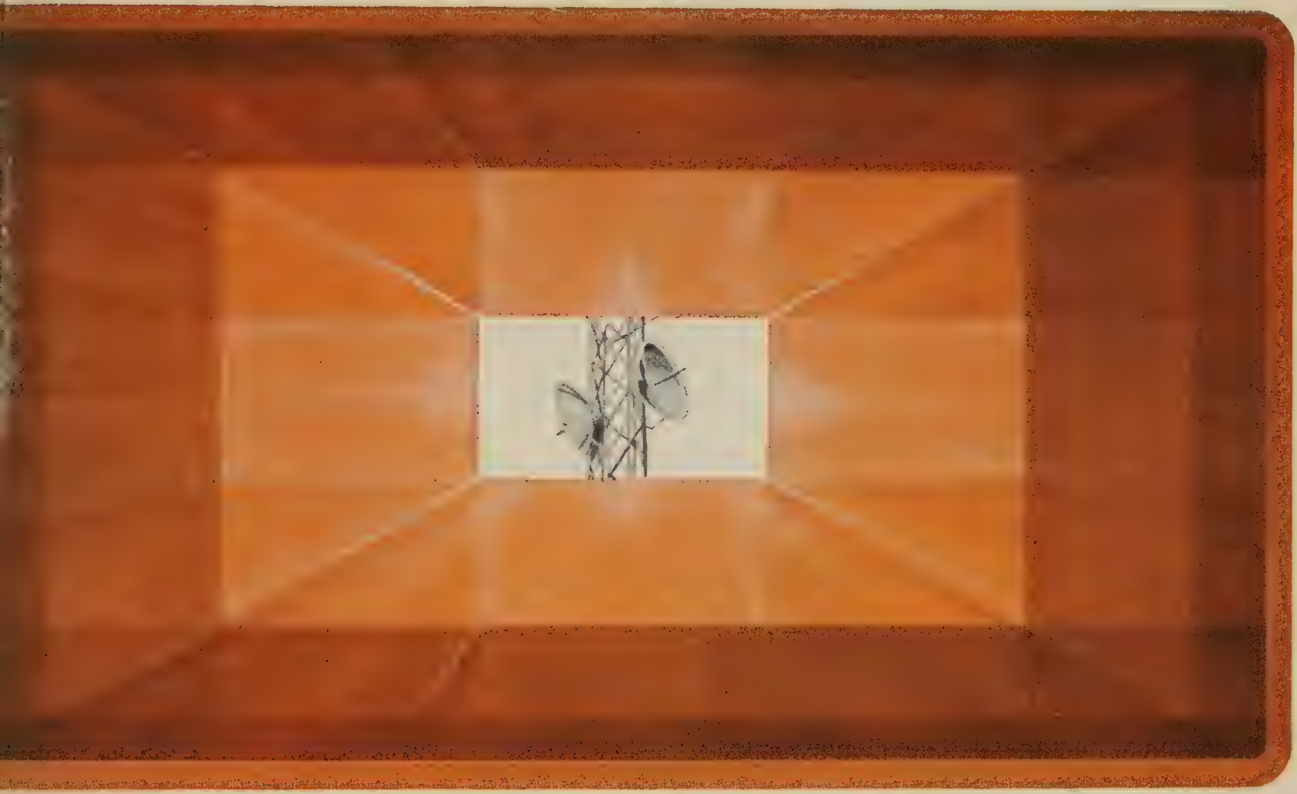
Dr. Attilio Melera has been named
the staff of Varian A. G., Swiss subsi
ary of Varian Associates, as a resear
chemist, according to Ralph Kane, Vi
President, International Operations.

Dr. Melera has spent the last thr
months at Varian's Palo Alto headqua
ters working with the staff of the firm
Applications Laboratory who conduct
program of research in nuclear magnet
resonance (NMR) and electron par
magnetic resonance (EPR) spectroscop
This group also makes its equipme
and experience available to assist i
terested scientists from universities, r
search institutions, and other industri
firms in the evaluation of these tec
niques for the solution of their chemic
problems.

At Varian A. G., Dr. Melera will ser

(*Continued on page 36*)

FROM THE MAKERS OF
STYROFLEX® COAXIAL CABLE...
PHELPS DODGE
RIGID RECTANGULAR SEAMLESS
WAVEGUIDES
...WITH MIRROR-SMOOTH FINISH!



Phelps Dodge waveguides are carefully extruded and cold drawn in rectangular seamless shapes from oxygen ree copper and commercial bronze, 90% for highest quality and finest performance at high frequencies.

Control of the inner surfaces of every guide is closely maintained by Phelps Dodge throughout fabrication to assure the most critical type of mirror-smooth finish —an essential for ultimate signal strength. All Phelps Dodge waveguides are made in accordance with applicable military and commercial specifications and are available in the following family of sizes:

RG-104/U · RG-112/U · RG-48/U · RG-49/U · RG-50/U · RG-51/U
RG-52/U · RG-91/U · RG-53/U · RG-110/U · RG-109/U

WR-229 · WR-159 · WR-75 · WR-51 · WR-34

Guides are fabricated in 12-foot mill lengths and in longer lengths on special order. Contact your Phelps Dodge representative for full information.

PHELPS DODGE COPPER PRODUCTS
CORPORATION
300 Park Avenue, New York 22, N.Y.

P D

Circle Reader Service Card 29

SPERRY Microline®
Microwave Instruments for Power Measuring and Detecting

WAVEGUIDE BARRETTER MOUNT

Broadband—covers complete waveguide frequency range; fixed-tuned mounts; designed for average and peak power measurements; barretter replacement without returning mount; light-weight precision cast aluminum. Covers the complete frequency range, 2.6-12.4 kmc. $70 to $150.

COAXIAL THERMISTOR MOUNT—Model 33B2
COAXIAL BARRETTER MOUNT—Model 33B3

Here are 2 wide frequency range instruments, with low-SWR whose elements are easily replaceable by user. Specially designed for the Microline 31A1. May also be used with any standard power meter.

SPECIFICATIONS

Frequency Range — 0.1-10 kmc less than 1.5 over .1-10 kmc
Connectors — Male type N input, Female BNC output

TUNABLE DETECTOR MOUNTS

Tunable detector mounts are used extensively in microwave setups with crystals, barretters, and thermistors to detect, monitor, and measure microwave energy. Full waveguide bandwidth coverage, they have a wide tuning range for impedance matching. Same frequencies as waveguide barretter mounts, $75 to $180.

BARRETTERS AND THERMISTORS

Sperry also stocks a complete line of Sperry Microline barretters and thermistors for use with these instruments.

SPERRY

SPERRY MICROWAVE ELECTRONICS COMPANY,
Clearwater, Fla., Division of Sperry Rand Corp.

(Continued from page 34)

on the staff of a similar applications laboratory which makes NMR and EPR research available to scientists throughout Europe, Africa and the Middle East. Both NMR and EPR spectrometers, which provide highly accurate and non-destructive methods of analysis, were first commercially developed at Varian.

Dr. Melera, a native of Giubiasco, Switzerland, received his PhD degree from Eidgenossische Technische Hochschule in Zurich. Before joining Varian, he served as a research assistant at Stanford University for two and one-half years where he was involved in research on molecular structures of natural products. He is the author of a number of papers for scientific journals.

Varian A. G. was formed in October of last year to facilitate Varian's participation in the overseas market. Dr. Warren Proctor is managing director of the subsidiary firm which is headquartered at Zug. The applications laboratory is at Zurich.

— *mwj* —

KAMEN FORECASTS PORTLAND BOOM

Better days ahead have been promised for Portland, Maine which has been termed a labor distress area, by Ira Kamen, newly elected president of Portland Industries Corp., South Portland, Maine.

In projecting the prospects for Portland Industries, Mr. Kamen stated: "I am now in the process of integrating its facilities and skilled manpower with creative engineering associates, so that the reorganized Portland Industries team becomes capable of efficiently programming and producing the most complex electronic and nuclear projects for the space age. When Portland Industries is producing full blast, Portland, Maine should no longer be a labor distress area, for this plant has a capacity of well over $30,000,000 yearly volume, and can employ 3,000 people, which this installation did during the war."

Mr. Kamen went on to say as an example, that Portland's buildings can accommodate complete sectional para
antennas as large as 130 feet. This m
that large antennas can be built, as
bled and tested indoors with work g
on uninterruptedly 365 days a year.

Mr. Kamen joins Portland Indus
after serving ten years with the Ge
Bronze Corp. as divisional vice-presic
in 1958 he was elected vice-presiden
the parent company. He has more
20 years experience in the electr
industry, having served as consultan
RCA, Paramount Pictures Corp., the
Navy and Temco. He is a senior m
ber of IRE and a member of the R
Pioneers.

— *mwj* —

SYLVANIA APPOINTS SPINK VI PRESIDENT OF SALES

William O. Spink has been appoi
Vice President of Sales for Sylvania E
tronic Tubes, a division of Sylv
Electric Products Inc., New York, N
it was announced by Matthew D. Bu
president of the division. Sylvania
subsidiary of General Telephone & E
tronics Corp.

Mr. Spink, who has been equipn
sales manager for the division since 1
succeeds Donald W. Gunn, who has b
named Western Region Vice Presic
for the company. In his new post,
Spink has over-all responsibility
sales of the company's receiving tu
microwave devices, television pic
tubes, and other cathode ray tubes to
government and to Sylvania distribu
and original equipment customers.
will continue to have his headquarter
Sylvania's sales office in New York C

A member of the Sylvania organizat
since 1947, Mr. Spink joined the E
tronic Tubes Division as a field engir
in Cleveland. Since that time he
held various sales executive positions
Cincinnati, Chicago and New York.

A native of Chicago, Mr. Spink
tended Northwestern University at Eva
ton, Ill., where he received a BS deg
in Electrical Engineering.

— *mwj* —

(Continued on page 39)

SPERRY *Microline*®

31A1

AVERAGE POWER METER

AVERAGE POWER METER MODEL 31A1
Microline

NOW!

EASURE POWER TO ± .03!

MOST ACCURATE instrument of its kind on the market. Has unmatched stability. Sperry Microline 31A1 can be used to measure pulsed or C-W power of radar, radio, television, microwave and microwave relay equipment and components. Priced competitively low.

EASY TO BALANCE. In addition, two scales (0-10 db and 5-15 db) permit its use for direct attenuation measurements. Its frequency coverage is limited only by the range of the bolometer and mount used. D-C bias adjustment is set by a 12-position switch.

Scales:	Five ranges, front panel selection: 0-.1, 0-.3, 0-1.0, 0-3.0, 0-10 milliwatts full scale. Two ranges 0-10, 5-15 db full scale. Higher power levels by using directional couplers and/or calibrated attenuators.
Accuracy:	3% of full scale reading.
Power:	105-125 volts, 210-230 volts, 50-60 cps.
Bolometer:	Temperature coefficient: positive or negative, front panel selected. Resistance: 100 or 200 ohms, front panel selected.
Bias Current:	0-16 ma d-c
Recorder Output:	0-1 ma, 1500 ohms, one side ground
Oscillator Frequency:	10.7 kc.
Weight:	Approximately 13 lbs.
Price:	$240.

SPERRY 50 YEARS 1910 1960

ERRY MICROWAVE ELECTRONICS COMPANY, *CLEARWATER, FLORIDA · DIVISION OF SPERRY RAND CORPORATION*

Circle Reader Service Card 31

Rexolite® and Brand-Rex Technical Service Answer Most Microwave Insulation Problems

Across the microwave spectrum, from anode toppers to timing blocks; from antennas to duplexer pins, to filament cores, to light pipes, phaser assemblies and probe insulators; from slot arrays to slip ring disks and sweep arms, to transformer locks and cores, to timers and tubes . . . Rexolite plastic dielectrics and Brand-Rex technical service have teamed to stamp "solved" on a long list of complex microwave insulation problems.

And, it's an impressive reason why! Rexolite thermosetting materials offer a wide range of UHF electrical properties and advantages . . . low loss factor, low dielectric constant, and exceptional resistance to radiation. Pure research into dielectrics at the Enka Research Center in North Carolina and applied research and development by the Technical Development Group at the Acton, Mass., plant have resulted, and will continue to result, in significant new Rexolite types. Adding to its usefulness, Rexolite is available in rods and both plain and copper clad sheets which can be machined into an infinite number of simple or complex shapes.

BRAND-REX
REXOLITE

A few minutes spent with samples and comprehensive Rexolite technical data will most surely be a profitable investment for you. Brand-Rex technical service engineers will gladly help, too. A note or call from you is all we need.

BRAND REX

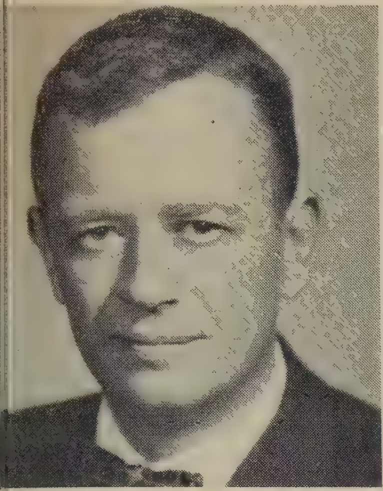
WILLIAM BRAND-REX DIVISION
American ENKA Corporation
DEPT. R, 37 SUDBURY ROAD, CONCORD, MASSACHUSETTS
Telephone: EMerson 9-9630

Vinyl, Teflon, Polyethelene, Nylon and Silicone Rubber Wires and Cables
Electrical Tubing and Sleeving — UHF Cast Plastics — Plastic Extrusions

Circle Reader Service Card 32

(*Continued from page 36*)

JAYNE APPOINTED TO ANAGERIAL POST AT TURBO



urbo Machine Company, Lansdale,
has announced the appointment of
nklin B. Jayne as manager of engi-
ring, Ordnance and Electronics De-
ment.

r. Jayne came to Turbo from Philco
p., where he was Manager of the
e & Microwave & Antenna Group of
pon Systems Division, Government
Industrial Group.

r. Jayne did graduate work at the
versity of Pennsylvania, after attend-
the United States Naval Academy
the University of Pennsylvania.

le is a senior member of the IRE
active in three of its professional
ups: Engineering Management, An-
na & Propagation, and Microwave
eory & Techniques. In addition, Mr.
ne is a member of Franklin Institute
Philadelphia and the Philadelphia
demy of Natural Sciences.

—*mwj*—

EW ACQUISITION RADAR FOR IKE-HERCULES DEVELOPED BY GENERAL ELECTRIC

An advanced high power, long-range
quisition radar which more than tri-
s the defensive capabilities of the
sent Nike-Hercules Weapons System
s been developed by the General Elec-
Company, it was disclosed recently
Mr. J. J. Farrell, General Manager of
Company's Heavy Military Elec-
nics Department, Syracuse, N.Y.

The prototype of this new radar is
talled at the White Sands Missile
nge in southern New Mexico. It
yed a key role in an August test in
ich the destruction of a Hercules mis-
e by another Hercules missile was
complished by providing precise, long-
nge acquisition data. This missile
ill" represents one of the most difficult
t achieved to date in this area be-
use of the relatively small target size
d high speed capabilities of the target
ssile.

The improved Nike-Hercules Weapon
stem is capable of detecting, tracking
d destroying any air-supported target

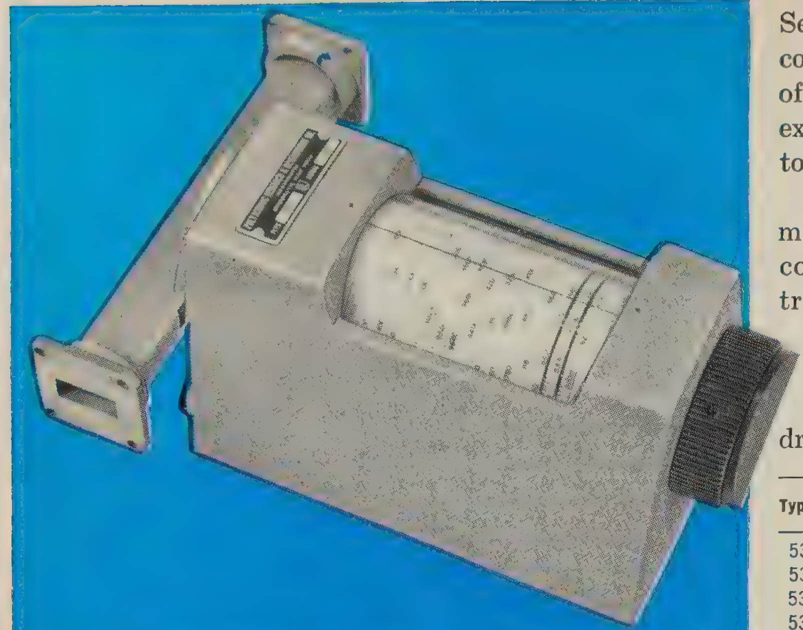
(*Continued on page 42*)

**Next week
we'll unveil our
243rd microwave
product, to be followed
just as rapidly by other
dramatically-new and constantly improved
products. Microwave is changing! Do you specify
microwave equipment which is already obsolete?**

DON-LAN ELECTRONICS, INC.
1131 Olympic Boulevard, Santa Monica, California
a division of Regan Industries, Inc.

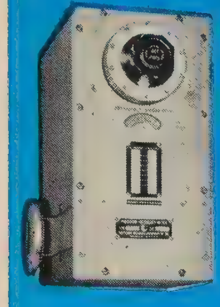
**Write for data on latest waveguide switches,
co-axial switches, miniature antennas,
attenuators and diversified microwave hardware.**

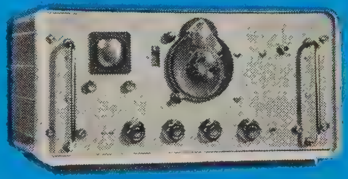
Circle Reader Service Card 33

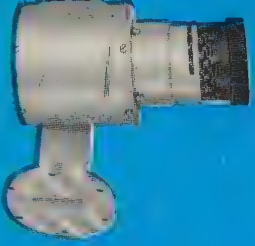


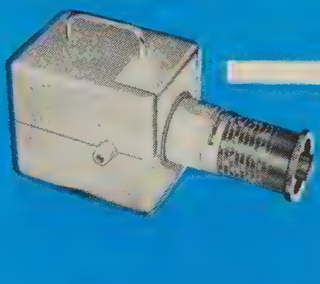
PRD

PACEMAKER LINE









Seven full waveguide bandwidths are eac covered by a separate meter in this 532 seri of nine reaction-coupled frequency meter extending over the complete range from 3.9 to 40.0 kmc/s.

These frequency meters consist of a TE_1 mode cavity resonator tuned by a no contacting plunger. Ruggedness for lor trouble-free life is assured by the all-met housing. Maximum readability, resolutic and accuracy to ±0.08% are the result an optimized design distinguished by drum type spiral scale more than 8 feet lon

Type No.	Frequency Range (kmc/sec)	Waveguide (Size in Inches)	Flange	Accuracy (%)	Pric
532	3.95 to 5.85	2 x 1	UG-149/U	±.08	$38
533	5.85 to 8.2	1½ x ¾	UG-344/U	±.08	$29
534	7.0 to 10.0	1¼ x ⅝	UG-51/U	±.08	$29
535	8.2 to 12.4	1 x ½	UG-39/U	±.08	$17
536	12.4 to 18.0	.702 x .391	UG-419/U	±.1	$28
537	18.0 to 26.5	.500 x .250	UG-425/U	±.1	$29
537-F1	18.0 to 26.5	.500 x .250	UG-595/U	±.1	$29
538	26.5 to 40.0	.360 x .220	UG-381/U	±.2	$30
538-F1	26.5 to 40.0	.360 x .220	UG-599/U	±.2	$30

BROADBAND

DIRECT READING FREQUENCY METERS

Most Complete Line . . .
For Every Purpose, Every Budget

High Precision, Direct Reading Meters (0.015%)

Series 555 to 579 consists of 30 different types covering fro 0.925 to 39.0 kmc/s. Representing highest state of the a these frequency meters fully qualify as transfer or secon ary standards for exacting laboratory or production servic Features include: hermetically sealed invar cavity, tempe ature-compensation, high Q, optimum cavity geometry, hig conductivity plating. Price range: $1200.-$1500.

Precision Heterodyne Frequency Meter (0.002%)

PRD 504, for 100 to 10,000 mc/s with accuracy of 0.002% crystal check points every 5 mc/s and 0.03% or bett between check points. Automatic interpolation by uniq patented spiral-scale dial. Beat indication by both extern earphones and built-in CRT. Meter is self-contained a portable. Price: $695.

Inexpensive, Direct Reading Meters (0.08%)

Series 585-A to 590-A affords excellent accuracy at lowe cost from 5.1 to 10.0 kmc/s. Ideally suited for panel moun ing and systems use. Price range: $150.-$350.

Direct Reading UHF Meter (±0.2%)

PRD 587-A, covers range 250 to 1000 mc/s. Spiral dru scale 60 inches long enables precision direct reading. Ma also be used as a tunable narrow band filter. Price: $27

PRD ELECTRONICS, INC.
A Subsidiary of Harris-Intertype Corporation
Formerly Polytechnic Research & Development Co., Inc.
202 Tillary Street, Brooklyn 1, New York, ULster 2-6800
1608 Centinela Ave., Inglewood, Calif., ORegon 8-6922

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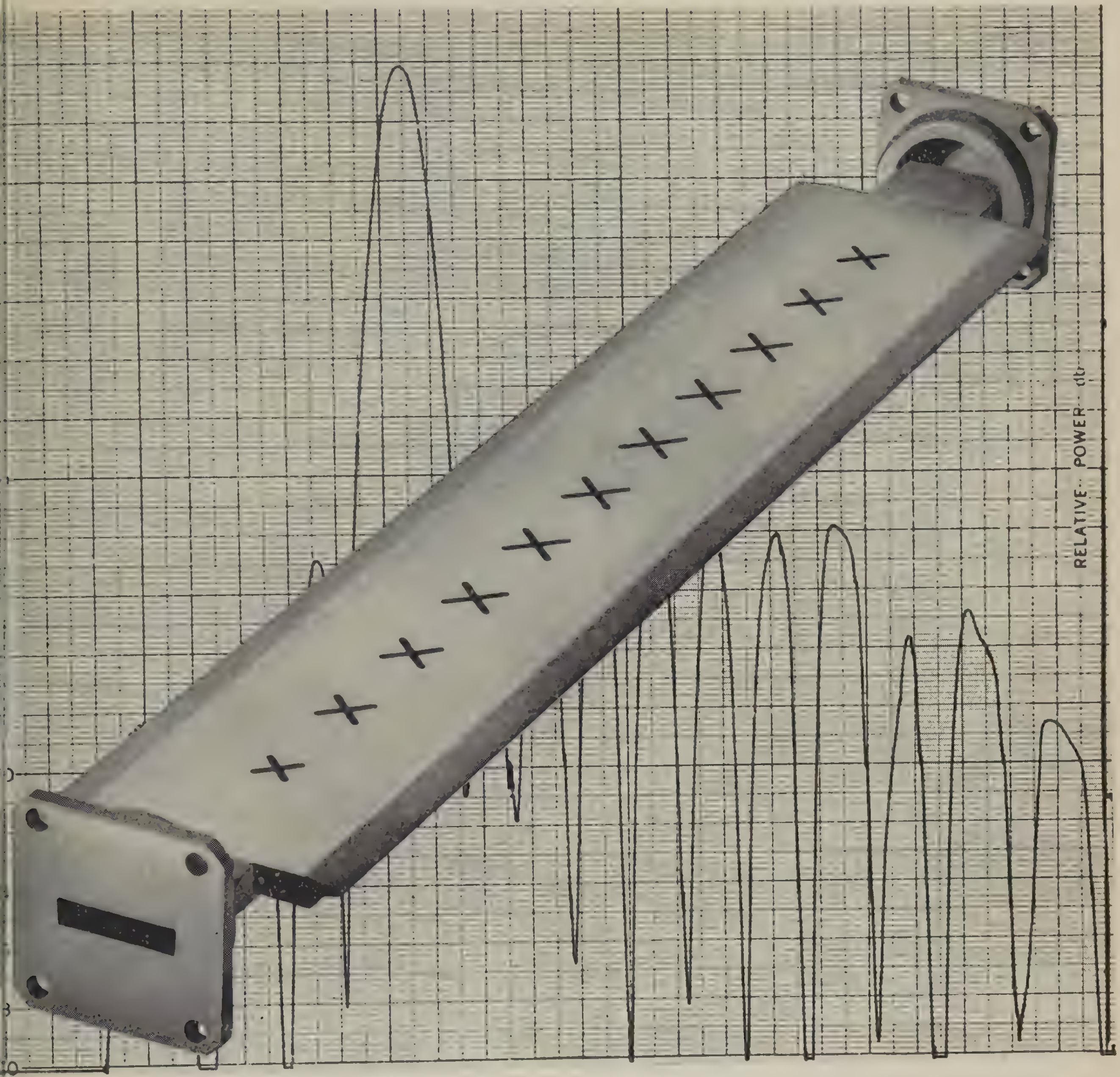
MICROWAVE ANTENNAS



Turbo pioneered the first full production of slotted antennas ten years ago. After a million slots and fifty thousand antennas, Turbo possesses unparalleled experience in the design, development and production of slotted line sources, flush-mounted systems and scanning arrays.

Competent engineers, advanced design techniques and modern development facilities at Turbo mean quick, economical solutions to your antenna problems.

Turbo's extensive manufacturing plant is available for quantity production. Close tolerances are maintained and Turbo offers production antenna pattern testing.

For the answers to *your* antenna problems, call or write to Turbo today.

TURBO

TURBO MACHINE COMPANY, LANSDALE, PA., U. S. A.

Circle Reader Service Card 35

(*Continued from page 39*)

in existence today, or now known to be on the drawing boards. Equally important, it has demonstrated its defense capabilities against tactical ballistic missiles of the field artillery type. The addition of the new acquisition radar known as HIPAR also provides the overall system with defense capabilities against air-to-surface missiles, and assures high performance despite attempts at sophisticated electronic jamming that could be a threat during the forthcoming decade.

In addition to longer range, the high gain, narrow beam antenna used by HIPAR provides high angle coverage. Its high altitude coverage also is appreciably better than most present-day acquisition, aircraft, early warning and surveillance radars.

To permit the full detection capabilities of the high gain antenna to be realized despite the presence of enemy jamming, unique Moving Target Indicator (MTI) and Receiver circuits have been developed for use with HIPAR. These circuits employ the latest anti-jamming techniques that provide capabilities not previously possible with conventional MTI techniques.

A new multi-megawatt Klystron tube, incorporating several significant improvements over previous designs has been developed to produce the high power, pulsed radio frequency (RF) energy transmitted by HIPAR. Manufactured by the General Electric Company's Power Tube Department in Schenectady, N.Y., the man-sized tube was developed at the company's Microwave Laboratory in Palo Alto, California.

—mwj—

PAPERS REQUESTED FOR 1961 WINTER CONVENTION ON MILITARY ELECTRONICS

The Winter Convention on Military Electronics, sponsored by the Institute of Radio Engineers Professional Group on Military Electronics, will be held on February 1, 2 and 3, 1961, in Los Angeles, Cal. Technical papers for the sessions of the conventions are solicited.

A series of classified sessions under the sponsorship of the Military are planned. For these sessions, each author will be responsible for obtaining the proper clearances for his paper, which must be limited to CONFIDENTIAL.

Conference Proceedings are not planned for this convention. However, abstracts of all papers will appear in the final Convention program. Authors are encouraged to submit their papers for publication in the "Transactions of the IRE." They are also urged to submit pre-prints at the Convention.

All material to be considered for presentation must be in the form of 100 word abstracts and 500 word summar
Material must reach the Technical F
gram Committee by 15 November, 19
All papers and correspondence should
sent to: Dr. John J. Myers, Hoffm
Electronics Corp., Military Products D
3717 S. Grand Avenue, Los Ange
California.

The Technical Program Committee
notify authors of acceptance of papers
early December.

—mwj—

LFE NAMES INSTRUMENT DIVISION SALES MANAGER

Perry Pollins has been named to
new post of sales manager for the Inst
ments Division of Laboratory For El
tronics, Inc., Boston, Mass. His respor
bilities include all direct sales
advertising for the Division.

Now in his eighth year with LFE,
Pollins was most recently field rep
sentative for the company's Commerc
Products Division. In other LFE po
he has been head of component testi
for quality control, head of the producti
test department, and an applications en
neer for the Office of Contracts Admir
tration.

Mr. Pollins was a Design Engin
with the Air Force Cambridge Resea
Center before joining LFE in 1952.

—mwj—

Men who know* prefer

ELDMEIER NAMED ASSOCIATE
DIRECTOR OF RESEARCH AT
PHILCO

onald G. Fink, director and general
ager of Philco Corp.'s Research Di-
on, Philadelphia, Pa. has announced
appointment of Dr. Joseph R. Feld-
er as associate director of research,
h responsibility in long range plan-
g of technical programs and "the
ntification of new areas of science and
nology of value to Philco."

r. Feldmeier, a graduate (BS) of
rnegie Tech in 1938, was awarded a
D degree in Physics by Notre Dame
iversity in 1942, whereupon he joined
staff of the M.I.T. Radiation Labora-
y where he engaged in the develop-
nt of magnetrons and radar transmit-
s. After World War II, he taught
ysics as assistant professor at Rutgers
iversity, and later founded the Physics
partment at the College of St. Thomas.
nce 1952, he has been associated with
Bettis Atomic Power Division of the
estinghouse Electric Corp. where he
ffed and directed research programs
the nuclear energy field. Dr. Feld-
ier has also served as consultant to
ustry and the university community
microwave and cosmic ray research
ojects.

A member of the American Physical
ciety, the American Association for
Advancement of Science and the
erican Nuclear Society, Dr. Feldmeier also holds membership in Phi Kappa Phi, Tau Beta Pi and Sigma Xi honorary fraternities. He has contributed to the technical literature through research in the fields of nuclear physics, microwave electronics, low temperature physics and atomic power reactors.

—*mwj*—

SYLVANIA APPOINTS BLACK MARKET MANAGER

The appointment of Paul B. Black as marketing manager of the Systems Engineering and Management Operation (SEMO) of Sylvania Electronic Systems, a division of Sylvania Electric Products Inc., New York, N.Y., has been announced by Richard W. Couch, manager of SEMO.

SEMO is responsible for obtaining, system engineering, and managing all large military systems contracts for Sylvania, a subsidiary of General Telephone & Electronics Corp., and other GT&E subsidiaries.

Mr. Black previously served as manager of the B-58 Hustler program at the Buffalo Operations of Sylvania Electronic Systems. The company is responsible for development and production of the electronic defense system for the supersonic B-58 bomber, a system designed to baffle enemy radar and radar-guided missiles directed against the aircraft.

Mr. Black joined Sylvania Lighting Products, Salem, Mass., another division of the company, in 1940 as a lighting engineer. Following World War II military service, he rejoined the company at Kew Gardens, N.Y., and was named head of the microwave circuits group in the Physics Laboratory there in 1948.

He served successively as engineering manager of the Boston Engineering Laboratory and manager of the Avionics Laboratory, a unit of Sylvania's Waltham Laboratories, before appointment as manager of the B-58 Hustler program in February, 1956.

Mr. Black is a member of the American Management Association and the Institute of Radio Engineers.

(*Continued on page 72*)

You join the ranks of those who know* when you specify McMillan absorbers for *your* "free space" rooms The list of McMillan customers is a veritable "who's who" in the electronics industry and includes such leaders as — Avco, Bell Labs, Bendix, Cambridge Research Center, Convair, General Electric, Johns Hopkins, MIT Lincoln Labs, Philco, Westinghouse and many others.

McMillan absorbers

* KNOW that from McMillan they can obtain substantiation to back up performance claims — either in simple, concise form or in advanced, scientific data.
* KNOW that each and every piece of McMillan absorber must pass an adequate source inspection to assure conformance to electrical specifications.
* KNOW that McMillan absorbers can easily be attached and removed by anyone, without special tools and without the use of adhesives and the resulting damage to walls.

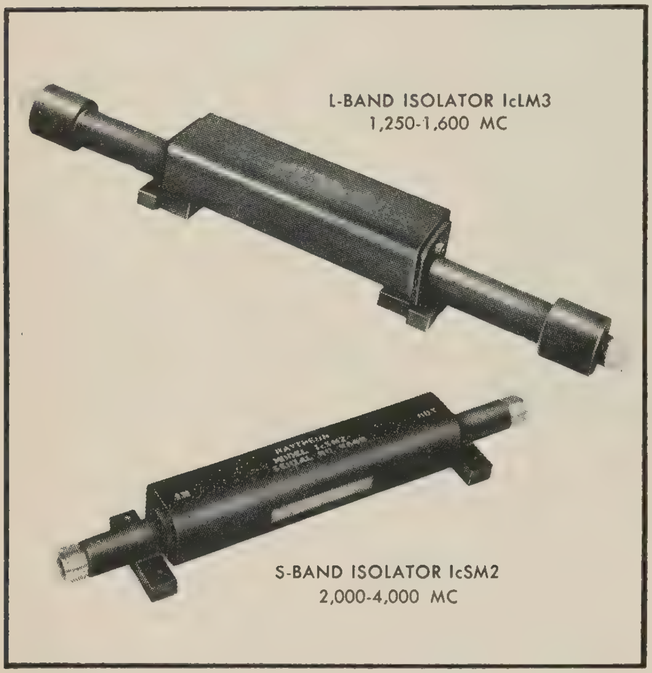
McMillan

McMILLAN LABORATORY, INCORPORATED
BROWNVILLE AVENUE • IPSWICH, MASSACHUSETTS

Circle Reader Service Card 36

RECENT RAYTHEON DEVELOPMENTS
IN MICROWAVE FERRITE DEVICES

BROADBAND COAX ISOLATORS FOR L&S BANDS



NEW COMPACT DEVICES PROVIDE MINIMUM ISOLATION OF 20 DB OVER EXTENDED BANDS

A single Raytheon L-band coaxial ferrite isolator nov covers the full frequency range from 1,250 throug 1,600 mc while its S-band sister covers the ban from 2,000 to 4,000 mc.

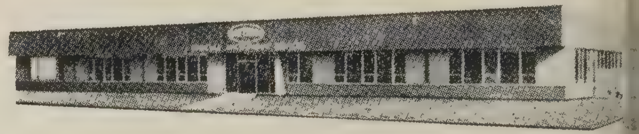
The new units, designated I_CLM3 and I_CSM2, ope new design possibilities in L and S band equipment Where performance over narrow frequency ranges i specified, increased isolation is possible with eithe unit.

To learn more about this significant development o other important Raytheon advances in microwav ferrite devices, please write, stating your particula area of interest, to the address below.

TYPICAL SPECIFICATIONS

	IcLM3	IcSM2
Frequency range	*1,250-1,600 mc*	*2,000-4,000 mc*
Isolation		
Minimum	*20 db*	*20 db*
Maximum	*40 db*	*31 db*
Insertion loss		
Minimum	*.8 db*	*1.3 db*
Maximum	*1.0 db*	*2.0 db**
Power		
Peak	*10 kw*	*5 kw*
Average	*25 watts*	*5 watts*
VSWR		
Minimum	*1.10*	*1.02*
Maximum	*1.25*	*1.25*
Weight (max.)	*3.8 lbs.*	*2.25 lbs.*
Max. dimension	*12 in.*	*9.8 in.*
Connectors	*Type N*	*Type N*

*1.0 db over narrow band.



THE MOST MODERN FACILITY devoted exclusively to microwave ferrite device and materials development, testin and production.

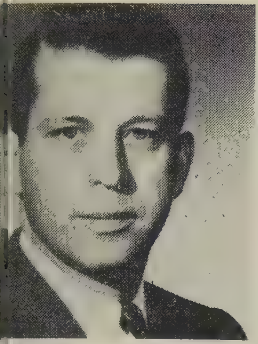
RAYTHEON COMPANY
SPECIAL MICROWAVE DEVICE OPERATIONS
WALTHAM INDUSTRIAL PARK
WALTHAM 54, MASSACHUSETTS

In Canada, contact Raytheon Canada, Ltd.
P. O. Box 142, Waterloo, Ontario

RAYTHEON EXCELLENCE IN ELECTRONICS

Circle Reader Service Card 37

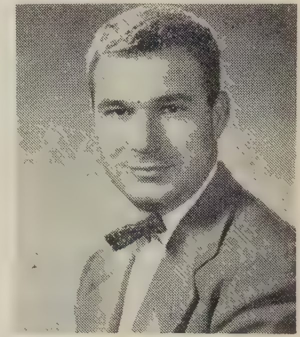
CONTRIBUTORS IN THIS ISSUE



SEYMOUR B. COHN, vice president and technical director of Rantec Corp., received a BE degree in Electrical Engineering at Yale University in 1942, an MS degree in Electrical Engineering in 1946 and a PhD degree in Engineering Sciences and Applied Physics in 1948 at Harvard University.

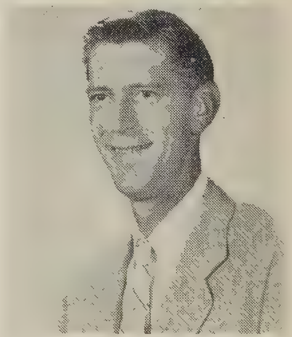
He has worked as a special research associate at Harvard's Radio Research Laboratory, as a research engineer in the Microwave Instruments and Components Dept. at Sperry Gyroscope Co. and as head of the Microwave group and manager of the Electromagnetics Laboratory at Stanford Research Institute.

Dr. Cohn is the author of several chapters on UHF and microwave filters in the book *Very High Frequency Techniques* and has contributed the chapter on Microwave Lens Antennas in *Antenna Engineering Handbook.* In addition, he has had over 30 papers published in various technical journals and is an Associate Editor of *the microwave journal.* Dr. Cohn is a Fellow of the IRE, a member of Tau Beta Pi and Sigma Xi and is now a member of the Administration Committee of the Microwave Theory and Techniques Professional Group.



MES W. CURRIE received a BS degree in general engineering from the U.S. val Academy in 1945. Prior to this, he completed three years of undergraduate k at the University of Alabama and has since done graduate work at Johns Hop- s University.

A registered professional engineer in Maryland, Mr. Currie has been 14 years n the Westinghouse Electronics Division, where he has been principally con- ed with the design and development of radar antennas. For the past eight years, has been an engineering section manager responsible for the development of cally new antennas, which included development of the air-supported Paraballoon® enna.



ARLES N. GOSNELL was born in Baltimore, Maryland in 1917. He is a uate of Johns Hopkins University and has a BS degree in chemical engineering.

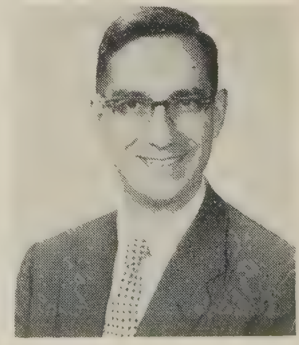
Since 1936 he has been working in the field of chemical engineering. He joined Electronics Division of Westinghouse in 1945 and spent ten years as a materials process engineer. He is presently a fellow engineer in the Antenna-Microwave velopment Section and has spent the last five years developing new materials and cesses for perfecting the Paraballoon® Antenna.

Mr. Gosnell holds one patent and has three patents pending. He has co-authored eral technical papers on the subject of air inflated structures. He is a member of the erican Chemical Society, American Society for Testing Materials and Society of stics Engineers.

EDWIN W. RICHTER was born in Queens, New York on November 26, 1922. He received a BS degree in Physics from Queens College, New York in 1943.

From 1943 to 1951 he was employed at the Columbia University Radiation Laboratory. From 1951 to 1954 he worked as a project engineer with the Electron Tube Division of Sperry Gyroscope Co. His principle occupation was the design of reflex klystrons for television relay applications.

From 1954 to 1958 he was a section head at the Missile Systems Division of Raytheon Co., where he worked on microwave tube and circuit problems. Currently he is employed as a senior scientist at Ewen Knight Corp. He has directed a radiometric sextant receiver program and is now engaged in millimeter radiometry and master amplifier research. Mr. Richter is a member of the IRE and the Institute for Navigation.



O YOUNG has been in the microwave field since 1949, working on antennas and rowave components and systems.

He obtained an MA degree in Mathematics from Cambridge University, England, 1945, and an MA degree in physics in 1947.

In 1953, he joined the Electronics Division of the Westinghouse Electric Corp. in timore, where he is now an advisory engineer. He obtained an MS EE degree from ns Hopkins University in 1956, was awarded the Westinghouse Electric Cor- ation's B.G. Lamme Graduate Scholarship in 1958, and obtained a Dr. Eng. degree he Johns Hopkins University in 1959.

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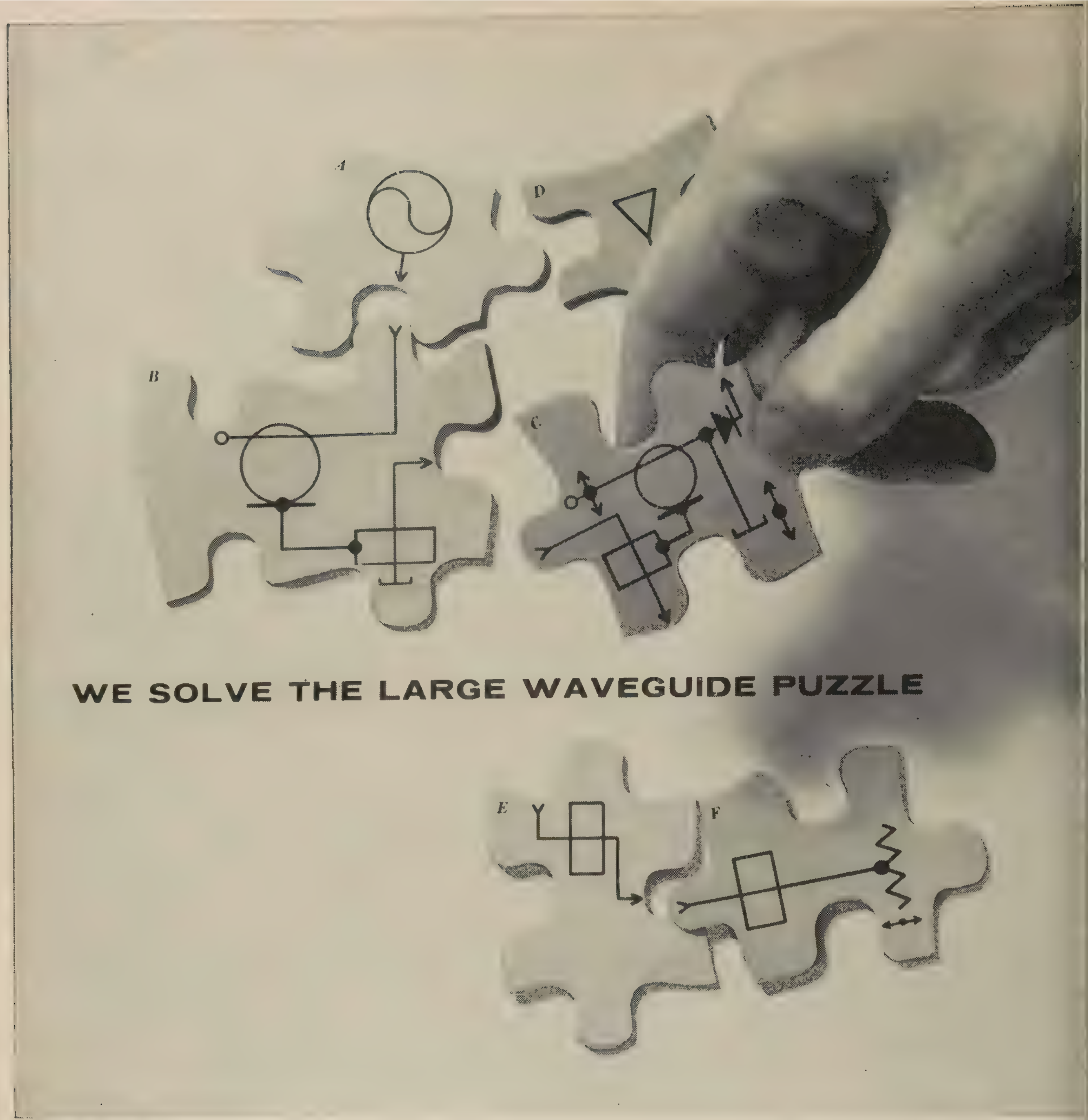

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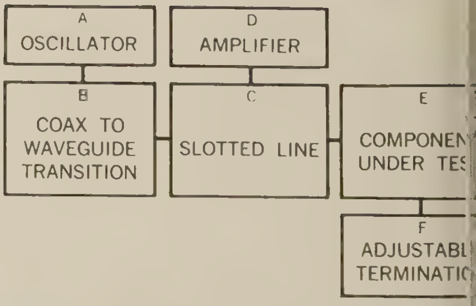
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PHASE-SHIFT
And TIME-DELAY RESPONSE
Of Microwave Narrow-Band Filters

SEYMOUR B. COHN*
RANTEC CORPORATION
Calabasas • California

INTRODUCTION

The phase-shift response of a transmission circuit is an portant consideration in the design of communication radar systems. In order to avoid overshoot, ringing broadening of signal pulses, the phase-shift versus quency characteristic must be closely linear over the dwidth of the signal spectrum.[1] Variation of the in- ion loss or gain of the transmission system over this dwidth will also introduce distortion, but usually non- earity of the phase-shift characteristic is far more ious in microwave systems.

The phase-shift response of a frequency filter cannot be ear at all frequencies. In fact, with the more commonly ed types of filters, there is considerable deviation from earity even inside the pass band. However, if the signal ndwidth is very small compared to the width of the ss band, the deviation from linearity of the phase charac- istic will be small over the width of the signal spectrum. is only in cases where the signal occupies an appreciable rt of the pass band that distortion due to phase curva- e is important. For that reason, in microwave applica- ns the phase characteristic is usually only of concern narrow-band band-pass filters, whose bandwidths are not ch wider than that of the signal spectrum. Consequently, this paper is primarily concerned with the most commonly used microwave narrow-band filter, the multiple-coupled-resonator filter designed to have either a maximally flat or equal-ripple insertion-loss response.[2, 3, 4, 5] In addition, consideration is given to the maximally flat-time-delay response,[6, 7] which may also be achieved in a multiple-coupled-resonator structure. The design data for all of these response functions are available in low-pass-prototype-filter form,[2, 3, 5, 7] as shown in Figure 1. Thus, the phase-shift calculations given here may be applied to low-pass, high-pass, and band-rejection filters, as well as to band-pass filters. In fact, for simplicity the graphical data are plotted versus the frequency parameter of the low-pass prototype, but are easily applied to narrow-band band-pass filters by means of formulas provided.

Although microwave signal spectra are usually narrow relative to their center frequencies, there are increasing applications utilizing pulse lengths of the order of a millimicrosecond where the relative width of the spectrum is large. For such cases, approximate synthesis procedures developed by Matthaei[8] may be used in designing the necessary wide-band filters. It is not known at this time whether or not the prototype-low-pass-filter phase-shift data contained in this paper can be applied to these wide-band filters, since they would be expected to deviate strongly from minimum-phase behavior.

It was once generally believed that a multiple-resonator-filter design based on a nondissipative prototype having maximally flat insertion-loss response is preferable to one

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This investigation was performed by the author at Stanford Research Institute, Menlo Park, California. The work was supported by the U.S. Army Signal Research and Development Laboratories.

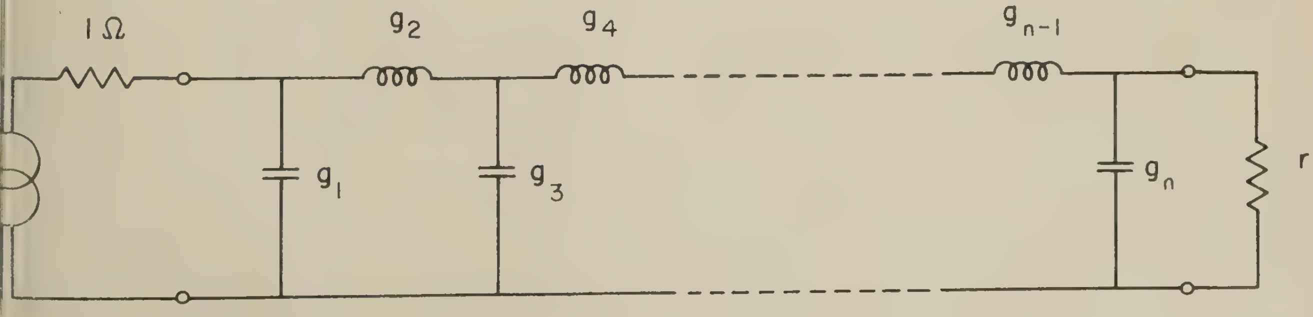


Figure 1 — Low-pass prototype filter.

having equal-ripple response. It has been demonstrated, however, that the nondissipative equal-ripple prototype design (with ripples of about 0.01 to 0.1 db) is superior in a number of respects. For a given number of elements and given stop-band bandwidth it yields better selectivity and lower pass-band dissipation loss.[9] Furthermore, the coupling elements are more nearly uniform than with the maximally flat design so that structural errors between their relative sizes are likely to be smaller.

Thus, from standpoints of selectivity, dissipation loss, and practical design the equal-ripple response is superior to the maximally flat insertion-loss response. However, it is still generally believed that the maximally flat insertion-loss filter provides a more linear phase characteristic than the equal-ripple filter, so that the former would be preferred where distortion might be a problem. In order to determine whether this is indeed true, a quantitative comparison of various five-element filters was made. The results show that in usual applications where the purpose of the filter is to provide isolation between channels, and not to limit the bandwidth of the signal spectrum, the maximally flat insertion-loss filter is actually likely to be inferior to the equal-ripple filter. In less usual applications where the filter's function is to decrease the bandwidth of the signal spectrum, so that the phase characteristic near and beyond the 3-db points is important, both types of response would usually give poor results, with the equal-ripple filter the inferior of the two.

It must be emphasized that the data and conclusions given in this paper apply only to five-element filters. It is believed, however, that similar performance will result with other numbers of elements, although quantitative values will be different. Therefore, in applications requiring linear phase shift and numbers of elements other than five, it is definitely worthwhile to carry out calculations like those in this paper to see which response function is most suitable. The formulas given in Part IV will make such calculations straightforward.

The maximally flat time-delay filter offers a phase characteristic greatly superior to that of the equal-ripple and maximally flat insertion-loss filters, but has a number of disadvantages that preclude its use in most cases: (1) Its insertion-loss response in decibels versus frequency approximates a parabolic curve, so that its VSWR increases rapidly as f deviates from the center frequency, f_0. Thus over most of its 3-db bandwidth the VSWR and reflection coefficient are high. As a result, reflection interactions with a slightly mismatched load or generator may seriously affect the otherwise good phase-shift response of this type of filter. (2) For a given selectivity more elements are needed. In fact, no matter how many elements are used, this type of filter cannot provide appreciably greater selectivity than a parabolic insertion-loss-response curve. (3) The multiple-resonator structure is highly unsymmetrical, with a very large variation in the coupling elements from one end to the other. This large variation increases the difficulty in the design, and makes values of the couplings more likely to be in error relative to each other. The only application for which the maximally flat time-delay filter may be preferable is one where the filter is intended to reduce the spectrum bandwidth without causing overshoot or ringing. The excellent linearity of the phase function even beyond the 3-db points makes this filter well suited for this purpose.

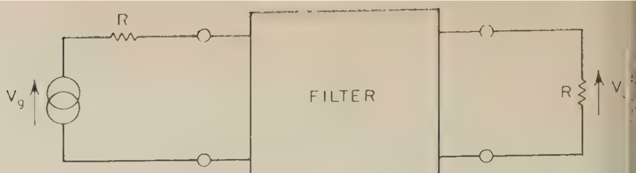


Figure 2 — Connection of filter to its termination.

II. TIME-DELAY AND PHASE-SHIFT RELATIONSHIP

The insertion loss in decibels of a filter operated b tween equal-resistance termination is defined as follows i terms of the quantities shown in Figure 2:

$$L = 20\log_{10}\frac{V_g}{2V_L} \qquad (1$$

The insertion phase shift of the filter is defined as

$$\phi = \angle\,(V_g/V_L = \tan^{-1}\frac{Im(V_g/V_L)}{Re(V_g/V_L)} \qquad (2$$

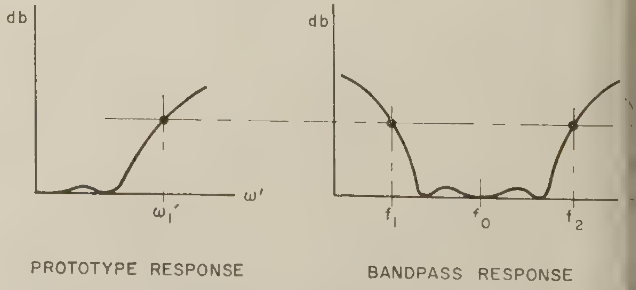
For ϕ in radians, the time delay in seconds of a sign passing through the filter from a matched source to matched load is

$$t_d = \frac{d\phi}{d\omega} \qquad (3$$

where ω is the angular frequency $2\pi f$ in radians p second.

If $d\phi/d\omega$ is not constant over the bandwidth of t signal spectrum (i.e., if ϕ vs ω is not linear), the tim delay will vary over different portions of the spectru and distortion will result. Thus, a constant time del over the spectrum width is necessary for distortionle transmission. In comparing different filters, the amou of deviation from constant time delay over the sign bandwidth provides a good indication of probable pe formance. Of course, insertion-loss variation over t bandwidth will also affect the fidelity of signal transmi sion, but in typical microwave applications this source distortion is not likely to be serious.

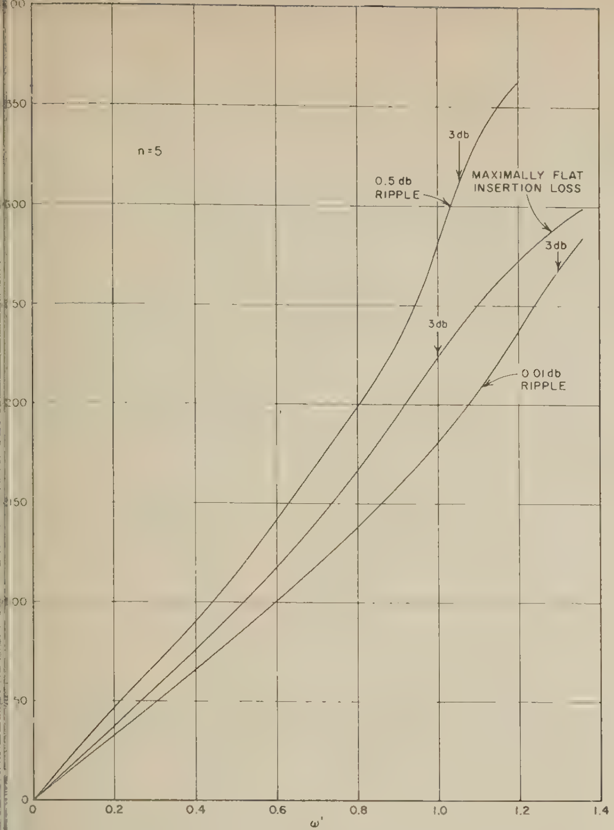
The phase-shift and time-delay curves presented in th paper were evaluated for the low-pass prototype filt appropriate to each response type. The phase-shift fun tion of the derived band-pass filter is obtained from the curves simply by transforming the frequency scale as show in Figure 3. Frequency transformation relations for number of kinds of coupled-resonator circuits have bee given.[2] In the case of narrow bandwidth (less than few percent), these all reduce to



PROTOTYPE RESPONSE

BANDPASS RESPONSE

Figure 3 — Correspondence between frequency scales for lo pass-prototype filter and equivalent band-pass filter.



ure 4 — Insertion-phase-shift response of five-element equal-ripple and maximally flat insertion-loss prototype filters.

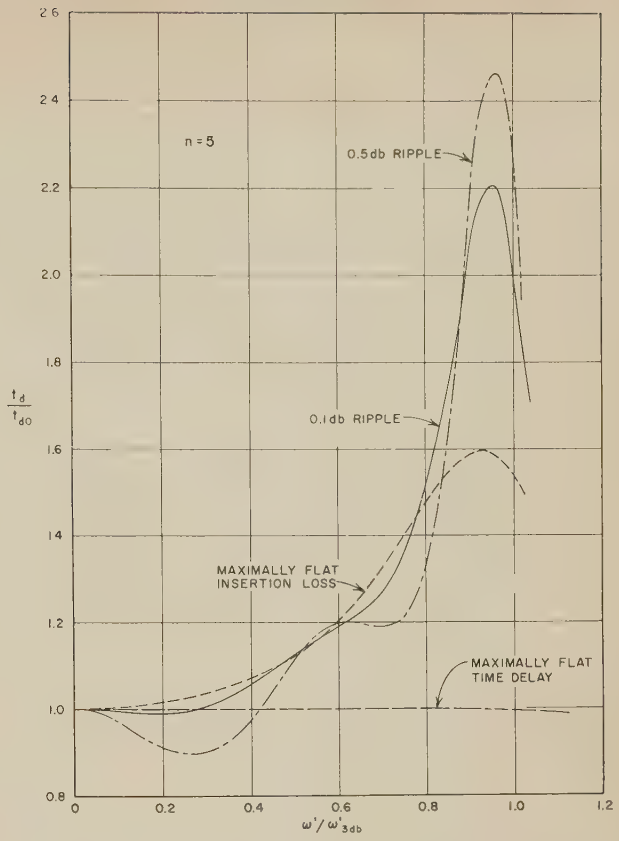


Figure 5 — Normalized time delay versus $w'/w'_{3\ db}$ for various prototype filters.

$$\omega' = \frac{2\omega_1'(\omega - \omega_0)}{w_1\omega_0} \qquad (4)$$

ere (see Figure 3) ω' is radian frequency for the low- ss prototype filter, ω_1' is a particular value of ω', $=2\pi f$ is radian frequency for the band-pass filter, ω_0 the center radian frequency of the band-pass filter, and

$$w_1 = \frac{\omega_2 - \omega_1}{\omega_0} \qquad (5)$$

the relative bandwidth of the band-pass filter between gular frequencies ω_1 and ω_2 that correspond to ′.

Equation (3) may be rewritten as

$$t_d = \frac{d\phi}{d\omega'} \cdot \frac{d\omega'}{d\omega} \qquad (6)$$

ere $d\phi/d\omega'$ is the time delay of the prototype filter. uations (4), (5), and (6) yield

$$t_d = \frac{\omega_1'}{\pi(f_2 - f_1)} \cdot \frac{d\phi}{d\omega'} \ . \qquad (7)$$

is formula enables one to calculate the time delay of narrow-band band-pass filter in terms of its bandwidth - f_1, the corresponding radian frequency ω_1', and the ne delay of the prototype filter. With filters of band- dth more than about two percent and not more than out 10 percent, Equation (6) should be used with a ore precise relationship between ω' and ω than Equa- on (4).[2]

The time-delay curves in this paper are normalized ith respect to the center-frequency time delay t_{d0}. Thus, absolute time delay values are desired, one need merely multiply the normalized values by t_{d0}, which may be calculated at f_0 by Equation (3), (6), or (7).

III. CALCULATED RESULTS

Phase-shift-versus-frequency curves are shown in Figure 4 for dissipationless low-pass prototype filters having maximally flat insertion-loss response and equal-ripple response with ripple levels of 0.01 and 0.5 db. The location of each 3-db point is indicated. All of the curves exhibit nonlinearity. The 0.5-db-ripple phase-shift curve has a minor undulation superimposed. This curve is typical of those for equal-ripple filters having high ripple amplitude, and explains why equal-ripple filters have had a poor reputation as far as phase linearity is concerned. However, the curve for 0.01-db ripple is strikingly improved, and in fact appears more nearly linear than the curve for the maximally flat insertion-loss case.

Normalized time-delay curves are shown in Figures 5 and 6. In Figure 5, the frequency scale is normalized with respect to the 3-db point, while in Figure 6 it is normalized with respect to the 60-db point. Inspection of Figure 5 shows that a high peak of time delay occurs just before the 3-db point. This peak is lowest for maximally flat insertion-loss response, and increases with ripple level in the equal-ripple cases. Thus, if important components of the signal spectrum extend out to or beyond the 3-db points, objectionable distortion is likely to occur in *all* cases, being least objectionable in the maximally flat insertion-loss case.

In usual applications, however, the signal spectrum will already be confined to a specific bandwidth before entering the filter. By making the filter passband sufficiently wider than the signal bandwidth, the spectrum may be limited to a portion of the time-delay curve that is almost constant. Figure 5 shows the equal-ripple filter to be superior in this case, if the ripple amplitude is of the order of 0.1 db. As an example, the curve for 0.1-db ripple is constant within ± 1 percent for $\omega'/\omega'_{3\ db} \leq 0.31$, while the curve for maximally flat insertion loss meets that tolerance only for $\omega'/\omega'_{3\ db} \leq 0.16$.

The curves in Figure 6 are even more interesting from a practical standpoint. In the usual application, the signal channel is to be isolated from one or more other channels spaced specified distances away in frequency. Thus, a normalization of the frequency scale such that the bandwidth at a given insertion-loss level in the stop band is the same for all curves provides a useful basis of comparison. In Figure 6, the frequency normalization is with respect to the 60-db point. However, the normalization point may be easily altered. In all cases, except the maximally flat time-delay case, the insertion-loss curves merge together and all increase at a 30-db per octave rate above about 50 db. Thus, the graph in Figure 6 may be applied to other values of stop-band insertion loss above 50 db merely by dividing the numbers on the abscissa scale by $10^{(L_s - 60)/20n}$, where L_s is the value of stop-band insertion loss, and $n = 5$ is the number of elements in the prototype filter circuit.

An interesting property revealed by Figure 6 is that the initial upward curvature of the time-delay curve for maximally flat insertion-loss changes gradually to downward curvature as the ripple level is increased. Close examination indicates that the initial curvature disappears for a ripple level of about 0.03 or 0.04 db. In addition to this effect on curvature, the equal-ripple case is also aided by its greater selectivity compared to the maximally flat case, permitting the former a wider pass band when the stop bandwidths are made the same. Comparisons of the curves show that for a ± 1-percent tolerance on t_d, a one-tenth-db-ripple filter can be used out to $0.106\omega'_{60db}$, while the maximally flat insertion-loss filter can be used only out to $0.040\omega'_{60\ db}$. For a ± 10-percent tolerance on t_d, a half-db-ripple filter can be used out to $0.184\omega'_{3\ db}$, while the maximally flat insertion-loss filter can be used only cut to $0.116\,\omega'_{3\ db}$. Thus, the improvement offered by equal-ripple filters with properly chosen ripple level is substantial.

Figures 5 and 6 show the maximally flat *time-delay* filter to have greatly superior time-delay characteristics to the other filters considered. However, its mismatch and design disadvantages discussed in Section I must be borne in mind in selecting the best filter for a given application. For example, at $\omega' = 0.1\,\omega'_{60\ db} = 0.645\,\omega'_{3\ db}$ the maximally flat time-delay filter has an insertion loss of 1.25 db due to reflection, and a VSWR of 3.0. The other filters, except for the 0.5-db-ripple one, are well matched these frequencies.

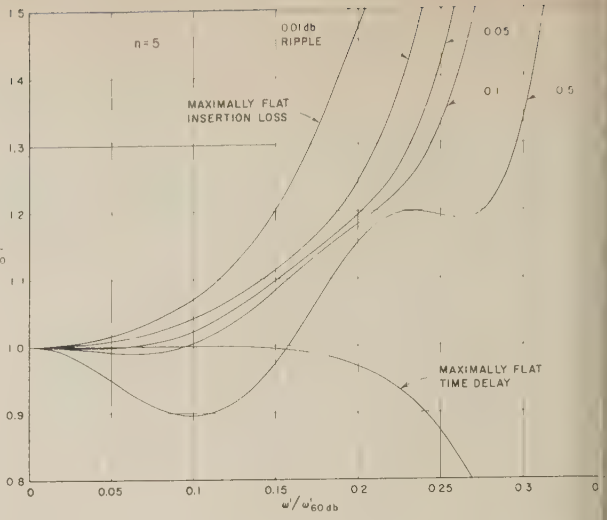


Figure 6 — Normalized time delay versus $w'/w'_{60\ db}$ various prototype filters.

IV. FORMULAS USED FOR PHASE-SHIFT CALCULATIONS

The following formulas were used in computing t insertion-phase-shift and time-delay data of Figures 4, and 6. They are given in generalized form so that t reader may use them for other values of ripple amplitu and n.

The insertion voltage ratio of a nondissipative equ ripple prototype filter may be determined in magnitu and phase from the following polynomial function:

$$P_n(p, x) = p^n + f_{n-1}(x)\,p^{n-1} + f_{n-2}(x)\,p^{n-2} + \ldots, \qquad ($$

where $p = \sigma + j\omega'$ is the complex radian-frequen variable, n is the degree of the polynomial, and x is parameter related to the ripple level. For steady-state e citation at frequency $p = 0 + j\omega'$, the insertion phase sh is given by

$$\phi = \tan^{-1}\left[\frac{\text{Im } P_n(j\omega', x)}{\text{Re } P_n(j\omega', x)}\right], \qquad ($$

while the insertion voltage ratio is simply proportional $|P_n(j\omega', x)|$. For n even, the polynomial $P_n(p, x)$ m be expressed in factored form by,[10]

$$P_n(p, x) = \prod_{m=1}^{n/2}\left[p^2 + \left(2x\cos\frac{\pi(2m-1)}{2n}\right)p + x^2 + \sin^2\frac{-(2m-1)}{2n}\right] \qquad (1$$

and, for n odd and ≥ 3, by

$$P_n(p, x) = (p + x)\prod_{m=1}^{(n-1)/2}\left[p^2 + \left(2x\cos\frac{\pi m}{n}\right)p + x^2 + \sin^2\frac{\pi m}{n}\right]. \qquad (1$$

The parameter x is given by[10]

$$x = \sinh\left[\frac{1}{n}\sinh^{-1}\left(\frac{1}{0^{L_m/10}-1}\right)^{1/2}\right] \qquad (1$$

where L_m is the ripple level in decibels; i.e., the differen decibels between the maximum and minimum in-tion loss in the pass band of the prototype filter. The ative insertion voltage ratio, $|P_n(j\omega', x)|$, has equal-ple behavior in the range $-1 \leq \omega' \leq 1$, and increases notonically outside that range.

Multiplied-out forms of $P_n(p, x)$ are given by Mat-ei[10] for $n = 2$ to 5, and his expression for $P_5(p, x)$ s used with Equation (12) in computing the data in s paper. Alternatively, the insertion phase shift is ual to the sum of the phase angles of all the individual tors in Equation (10) or (11).

Each quadratic factor in Equations (10) and (11) can reduced to a pair of binomial factors $(p - p_m)$ $- p_m^*)$, in which p_m and p_m^* are a complex-njugate pair of roots of the polynomial. For n even,

$$p_m = -x \cos\frac{\pi(2m-1)}{2n} + j\sqrt{x^2+1}\,\sin\frac{\pi(2m-1)}{2n} \qquad (13)$$

for n odd,

$$p_m = -x \cos\frac{\pi m}{n} + j\sqrt{x^2+1}\,\sin\frac{\pi m}{n}\,. \qquad (14)$$

ese formulas give pairs of roots p_m and p_m^* for $m \geq 1$. addition, the polynomial for n odd has a single root $= -x$. When plotted in the complex $p = \sigma + j\omega'$ ne, the roots of the polynomial all lie in the left half ne on an ellipse whose major axis coincides with the axis and whose minor axis coincides with the σ axis. e axial ratio of the ellipse varies with the ripple level, ellipse becoming a circle as the ripple level goes to . In that limit, the insertion-loss response becomes ximally flat, with its 3-db point at $\omega' = x \rightarrow \infty$.

When the frequency scale for the maximally flat in-$= 1$, the formulas for the polynomial and its roots p_m, $= 1$, the formulas for the polynamial and its roots p_m, * are as follows: for n even,

$$P_n(x) = \prod_{m=1}^{n/2}\left[p^2 + \left(2\cos\frac{-(2m-1)}{2n}\right)p + 1\right], \qquad (15)$$

$$p_m = -\cos\frac{\pi(2m-1)}{2n} + j\sin\frac{\pi(2m-1)}{2n}\,, \qquad (16)$$

for n odd,

$$(x) = (p+1)\prod_{m=1}^{(n-1)/2}\left[p^2 + \left(2\cos\frac{\pi m}{n}\right)p + 1\right]. \qquad (17)$$

$$p_m = -\cos\frac{\pi m}{n} + j\sin\frac{\pi m}{n}\,,\ m \geq 1 \qquad (18)$$

$$p_o = -1 \qquad (19)$$

The phase-shift data for the maximally flat and equal-ple-insertion-loss examples considered in this report re evaluated by means of an electronic computer. The ne-delay values were later obtained from the phase-ft values by numerical differentiation. The increment d, $\triangle\omega' = 0.05$, is fine enough to ensure very good uracy except at the high peaks near the 3-db points, ere a slight error may exist.

V. CONCLUSIONS

The investigation described in this paper was restricted to narrow-band filters based on five-element, nondissipative, low-pass prototypes. However, the results for numbers of elements other than five are expected to be similar although with quantitative values changed.

For $n = 5$, if the bandwidth of the signal spectrum is less than half of the 3-db bandwidth of the filter, the equal-ripple design with proper choice of ripple level offers superior phase-shift and time-delay characteristics compared to the maximally flat insertion-loss design. When the spectrum is less than or equal to three-tenths of the 3-db bandwidth, best results are obtained with ripple levels of about 0.03 to 0.1 db.

In most cases, a microwave filter is intended to isolate the signal spectrum from adjacent channels. The stop-band bandwidth is then a specified quantity. On the basis of equal stop-band bandwidth, equal-ripple filters offer a strong advantage over maximally flat insertion-loss filters. As an example, for a plus-or-minus one-percent tolerance on time-delay, an 0.1-db ripple filter can transmit a signal spectrum bandwidth that is 18.4 percent of the 60-db stop-band bandwidth, while for the maximally flat insertion-loss filter this figure would be only 11.6 percent.

In some applications, a filter is used to reduce the width of the signal spectrum. This may be done either to remove undesired portions of the spectrum or to broaden the pulse width intentionally. Both the maximally flat insertion-loss and equal-ripple designs are likely to cause ringing and overshoot when used for this purpose. More suitable for such applications is the maximally flat time-delay filter. This has a very flat time-delay characteristic over the pass-band and well beyond the 3-db points. However, its disadvantages of pass-band mismatch, poor selectivity, and practical design difficulties limit its application to cases where an equal-ripple-insertion-loss design will not suffice.

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Electromagnetic Properties of
FERRIMAGNETICS
AND THEIR APPLICATIONS
From UHF to Millimeter Wave

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SECOND OF THREE PARTS

III. SPIN WAVES

The importance of spin waves in ferrites and ferromagnetic materials has emerged from a theoretical concept and, during recent years, the subject has become of great practical interest. The particular significance to ferrite applications was recognized in connection with the high-power problem. Direct experimental verification of the spin waves was most dramatically demonstrated in spin-wave resonance experiments[22] at microwave frequencies in thin films of permalloy. Perhaps it is appropriate to introduce this topic by discussing this particular experiment and the theory of spin-wave resonance.

Spin Wave Spectrum.

The equation of motion for a classical spin wave[23] can be written in the form

$$\frac{d\vec{M}}{dt} = \gamma\;(\vec{M}\,\mathrm{X}\,\vec{H}) + \gamma H_{ex}\, a^2 \frac{\vec{M}\,\mathrm{X}\,\nabla^2\vec{M}}{|M|} \qquad (5)$$

where $\vec{M}$ and $\vec{H}$ are the total magnetization and magnetic field including the rf components. The exchange contribution has been accounted for by introducing a restoring term proportional to $\nabla^2\vec{M}$, where H_{ex} is the equivalent internal exchange field tending to align neighboring spins and *a* is the lattice constant. If Equation 5 is solved for the case where the direction of propagation of the spin wave is along the direction of the applied static magnetic field, then the frequency of the spin wave is given by

$$\omega_k = \omega_o + \omega_{ex}\, a^2 k^2 \qquad (6)$$

where $\omega_0 = \gamma H_0$ and $\omega_{ex} = \gamma H_{ex}$ and the frequency each of the spin waves in the series depends on its wa number, *k*. In a sample of thickness δ, which may l several thousand angstrom units in a thin metal film, o can specify[24] the wave vector in terms of the samp dimension as

$$k = n\pi/\delta \qquad (7$$

since the spin waves meet a discontinuity at the surfa and can be assumed to be "pinned" at the boundary. T result is significant in that the usual ferromagne resonance (the uniform precessional mode for whi $n = 0$) is supplemented by additional resonances higher wave number with a separation between neighbo ing peaks of

$$\triangle\omega = \omega_{n+1} - \omega_n = \omega_{ex}\left(\frac{\pi a}{\delta}\right)^2 \qquad ($$

The exchange field for a metal is of the order of 1 gauss corresponding to an exchange frequency $\omega_{ex} \approx 1$ cps. Consequently for a film thickness of several tho sand angstrom units, $\triangle\omega \approx 10^8$ cps. Thus the spacing the spin wave peaks should be of the order of 100 o steds. Seavey and Tannenwald[22] have shown that the are resolvable, have observed the spin wave spectrum to $n = 17$ and have measured the internal exchange fie for permalloy.**

The expression for the spin-wave frequency for a f rite (ellipsoid of revolution magnetized along the a of rotation) having millimeter dimensions or larg takes on a somewhat more complicated form

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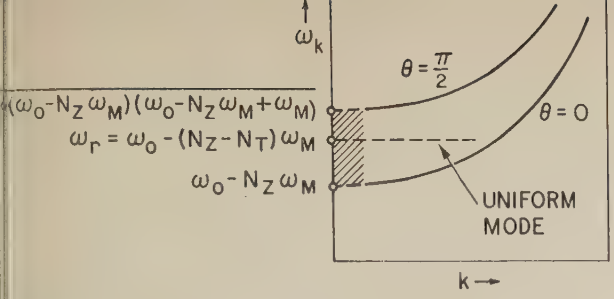
* *Operated with support from the U.S. Army, Navy, and Air Force.*

** A thorough description of spin wave concepts has been giv by P. E. Tannenwald, "Spin Waves," *the microwave journ* Vol. 2, pp. 25-28; July, 1959.



gure 14 — A plot of the spin wave spectrum from Equation 9 showing the degeneracy of the usual ferromagnetic resonance frequency (dashed line) with spin wave modes of different k and different directions of propagation. The shaded portion is the region of magnetostatic modes for $k \lesssim 2\pi/0.1d$ where d is the diameter of the specimen. The expressions on the axis were obtained from Equation 9 for $k = 0$ and ϑ as specified. The demagnetizing factors, N_z and N_T, parallel and transverse to the direction of the dc magnetic field adjust the expressions for specimens of different shape. (After H. Suhl).

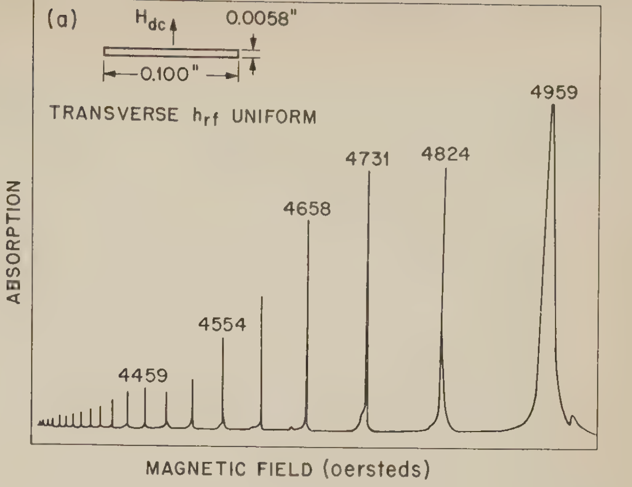


Figure 15 — Magnetostatic modes at 9222 mc in a thin disk of yttrium-iron garnet magnetized perpendicular to the plane with the uniform rf driving field applied in the plane of the disk. (After Dillon).

$$\omega_k = [(\omega_o - N_z\omega_M + \omega_{ex}\, a^2k^2)(\omega_o - N_z\omega_M + \omega_{ex}\, a^2k^2 + \omega_M \sin^2\theta)]^{1/2} \qquad 9)$$

ere $\omega_M = \gamma(4\pi M)$, N_z is the demagnetizing factor in direction of the dc magnetic field ($N_x + N_y + N_z$ 1) and θ is the angle between the field and the direcn of propagation of the spin wave. This expression is id for short wavelength (large k) compared to the nple dimension. Figure 14 shows a plot[25] from Equaa 9 of the spin wave frequency as a function of wave nber, k. The boundaries are curves for $\theta = 0$ and $= \pi/2$ corresponding to z-directed and transversely ected spin waves respectively. The curves turn upward r larger values of k when the term $\omega_{ex}\, a^2k^2$ becomes mparable in magnitude to the other terms of Equation The horizontal line on the figure corresponds to the ual ferromagnetic resonance frequency (of an ellipsoid agnetized in the z-direction) which can be seen to be generate with a large number of spin waves of different wave length and different directions of propagation. ence, any mechanism which couples energy between the iform precessional mode and the spin waves[26] introces losses and broadens the resonance line. These echanisms will be discussed presently.

Magnetostatic Modes.

In the spectrum of spin waves which exist in ecimens having finite boundaries, the uniform ecessional mode represents the zero-order spin wave. e expression for the resonant frequency of this ode including the consequences of the boundary-value eatment was developed by Kittel.[27] Other modes of nall wave number and different symmetries can also be cited in samples of finite dimension which correspond the shaded region of Figure 14. Unlike the shortavelength spin waves which can be represented by a m of plane waves, the analysis of the longer wavelength agnetostatic modes must include the surface demagtizing effects. The boundary value problem in this se is rather involved. However, it can be approximated treating the rf magnetic fields as one does in a magtostatic boundary value problem just as in Kittel's se. An extensive treatment has been carried out by alker[28] and these magnetostatic modes have been called "Walker modes." They have been observed experimentally by White, Solt and Mercereau[29] and by Dillon[30]. These modes differ physically from the uniform precessional mode[31] in that the specimen may be placed in the microwave cavity at a nodal point of the rf magnetic field so that nonuniform precession can be excited. The wavelengths of the modes are larger than the sample dimension. However, a nodal point of the modes occurs inside the ferrite and the rf magnetization in one portion of the sample is out of phase with that of the adjacent segment. Clearly, a large number and variety of such modes can be excited. The higher the order of the mode the farther away is the frequency from that of the uniform mode. The intensity is also smaller as shown in Figure 15. The essential significance of these modes is that they demonstrate the existence of spin waves of low order and, in addition, they play an important role in the design of ferromagnetic amplifiers as modes of excitation for idler or signal frequencies.

An analysis of magnetostatic modes and spin waves showing the connection between the two types was made by Damon and Eshbach[32] in which they considered the somewhat-simpler boundary value problem of a semi-infinite thin slab magnetized parallel to the plane. They found that the magnetostatic mode spectrum extends over the same frequency range as that obtained by Walker for a spheroid, namely $\omega = \gamma H_i$ to $\omega = \gamma(H_i + 2\pi M)$. This range consists of two regions distinguished by a distinctly different mode characteristic in each. The first region, from $\omega = \gamma H_i$ to $\omega = \gamma(B_iH_i)^{\frac{1}{2}}$, contains modes which are spatially harmonic plane waves or standing waves in the direction transverse to the sides of the slab. The second region, from $\omega = \gamma(B_iH_i)^{1/2}$ to $\omega = \gamma(H_i + 2\pi M)$, contains only surface waves[33] with exponentially decaying amplitude away from the interface of the ferrite slab into the interior of the ferromagnetic medium. These two classes of magnetostatic modes merge smoothly into surface and volume spin wave modes at higher values of wave number, *k*. Some of the surface mode solutions correspond to the anomalous gyromagnetic modes, i.e., ferrite dielectric and ferrite-air modes

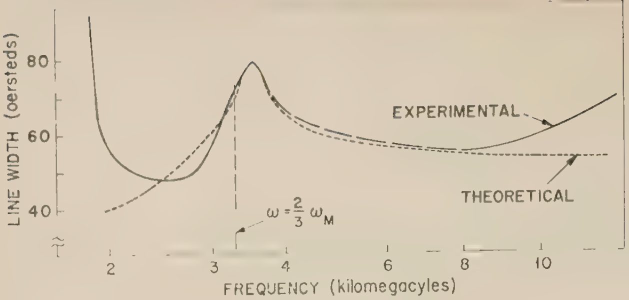


Figure 16 — Resonance line width of yttrium-iron garnet sphere as a function of frequency. Domain losses in unsaturated YIG broaden the line below 2000 mc. The peak near 4000 mc indicates coupling of energy from the uniform precession to a large number of spin wave modes of the same frequency. (After Buffler).

that occur in partially-filled rectangular waveguide.[4,10,11] The existence of these surface modes apparently has an important bearing, as we shall see, on the resonance line width problem since the line width is known to be influenced by the roughness of the surface.

IV. LINE WIDTH IN FERRIMAGNETS

It has been recognized for some time that the performance characteristics of nonreciprocal devices depends strongly on the ferromagnetic resonance line width[34] of the particular type of ferrite used. However, the basic physical mechanisms responsible for the breadth of the resonance line, particularly the role of spin waves in line broadening, were not understood until the behavior of ferrites was investigated under conditions of high signal power. More recently, the fundamental magnetic relaxation interactions have been described in detail through the study of ferrimagnetic garnets having resonance line widths about a hundred times smaller than ferrite lines. The contribution of impurities to the line width has also been recognized and demonstrated in garnets.

Role of Spin Waves.

Following the initial theoretical study of the nonlinear behavior of the spin system in high rf magnetic fields by Anderson and Suhl,[35] it was suggested by Clogston, Suhl, Walker and Anderson[36] that the large line width observed in ferrites ($\geq$ 50 oersteds) was caused, in part, by the excitation of spin waves having frequencies ω_k the same as the mode of uniform precession, as shown in Figure 14. They showed that the frequency of a spin wave with wave number *k* is given by Equation 9 and suggested that energy from the uniform precessional mode can be fed into the spin wave modes which thus causes an increase in the line width. Irregularities in the magnetic lattice provide a coupling mechanism. This basic concept of the excitation of spin waves has subsequently been supported by the additional analysis of Suhl[25] on the nonlinear behavior at high power levels. A convincing experiment verifying the Clogston model of the spin-wave contribution to the line width has been carried out by Buffler[37] whose results are shown in Figure 16. He measured the line width of the uniform mode for a polycrystalline garnet sphere as a function of frequency. Above 2000 mc, $\omega_0 > \omega_M/3$, the applied magnetic field is large enough to saturate the sphere and the line width reaches a minimum because the resonant frequency, $\omega_1 = \omega_0 = \gamma H_0$ is above the spin wave manifol and intersects only a small number of higher order spi waves. As the frequency is increased to $\omega_0 = 2\omega_M/3$, tl resonant frequency of the uniform mode is just equal the frequency at the top of the spin wave manifold give by the upper formula of Figure 14. Coupling to a max mum number of modes is possible and the line widt goes through a maximum. At higher frequency the un form mode approaches the bottom of the manifold whe there are fewer spin wave modes and the line width aga decreases.

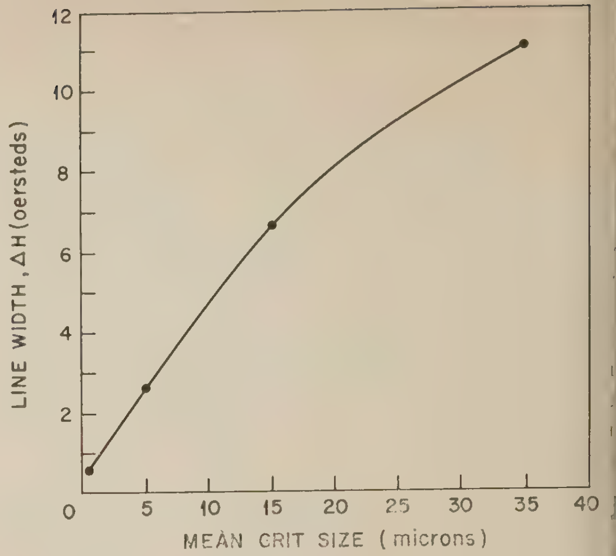


Figure 17 — Line width of yttrium-iron garnet at 9300 n *vs* the mean grit size of the polishing paper used to grir the spheres. (After LeCraw, Spencer and Porter).

Further insight into the nature of the interactions h emerged from the results of a number of microwa resonance experiments.[38] The extensive experiments LeCraw, Spencer and co-workers[39-42] are outstanding this respect. They showed that the measured line wid of YIG spheres can be reduced to a fraction of o oersted by successively finer surface polishing as show in Figure 17. This implies that the surface irregulariti caused by large-grit polishes couple the spin wave mode thereby broadening the resonance line. They provided fu ther confirmation of Clogston's hypothesis by doing similar resonance experiment on a thin disk magnetize perpendicular to the plane and found no surface poli effect. Since this latter configuration corresponds to tl

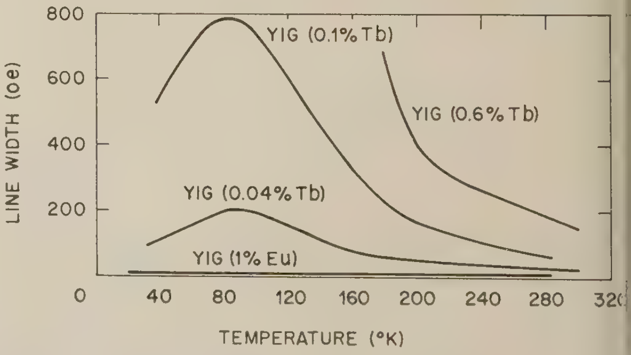


Figure 18 — Line width of yttrium-iron garnet at 24 kmc as function of temperature. Small concentrations of terbiu introduce large line-broadening effects. (After Dillon a Nielsen).

est allowed frequency on the axis of Figure 14 $_T$=0 for the disk), there are few spin waves having same frequency as the uniform precessional mode.

Role of Impurities.

he effect of impurities on resonance line width YIG was demonstrated by Dillon and Nielson[43] gure 18) and by Spencer, LeCraw and Clogs-[40] in their investigation of the resonance pro- ties as a function of temperature. The large width, with a peak at low temperatures, had n regarded as typical of some ferrimagnets until it shown to be caused by certain impurities[43,40] present very small quantities. Not only has extensive line adening been observed but also anomalous magnetic sotropy and modification of the g-factor, in some cases. physical phenomena involved have now been ex- ined theoretically by Kittel.[44] In particular, at room tem- ature and above, the rapid relaxation of the rare earth purities as compared to the magnetic ions in the normal lattices determines the g-factor and is responsible for large line width observed in some of these materials. very pure yttrium iron garnet that has been developed consequence of this research provides an ideal medium extending the basic studies of relaxation phenomena ferromagnetic materials. Using such ultra-pure speci- ns of YIG, Spencer and LeCraw have measured the -lattice* relaxation time.[42,45] They have also made asurements[41] under conditions of high-power satura- and used the relation $h_{crit} = \triangle H(\triangle H_k/4\pi M)^{1/2}$ determine $\triangle H_k$, the spin wave line width, as shown igure 19. Combining these results with their measure- ts of the total resonance line width as a function of ace roughness, Fletcher, LeCraw and Spencer[46] have cribed the nature of the relaxation process, shown in ure 20. They have shown that energy is transferred m the mode of uniform precession of the spin dipoles only directly to the lattice but also via the spin wave des which subsequently transfer the energy to the ice. Their latest experimental results have also been erpreted by Sparks and Kittel[47] who have described d calculated the detailed physical interaction between spin and the lattice.

NONLINEAR PROPERTIES OF FERRITES

The magnetic properties of ferrites are not linearly pendent on the rf field intensity at high signal power. is nonlinear behavior was first demonstrated in cavities a series of resonance experiments at high microwave wer by Bloembergen and Damon, by Damon[48] d by Bloembergen and Wang.[49] Some related ects in both cylindrical and rectangular wave- ide were reported by Sakiotis, Chait and Kales.[50] e nonlinear properties were first put to use through invention of the ferrite *frequency doubler* by Ayres, rtanian and Melchor.[51] The most significant advance in understanding of this phenomenon in ferrites was ovided by the theoretical work of Anderson and Suhl[35] ich was developed in detail by Suhl[25,52] who not only rnished an explanation of the high-power resonance ects that had been observed but also related the pheno- ena to the spin waves excited in these materials. Suhl

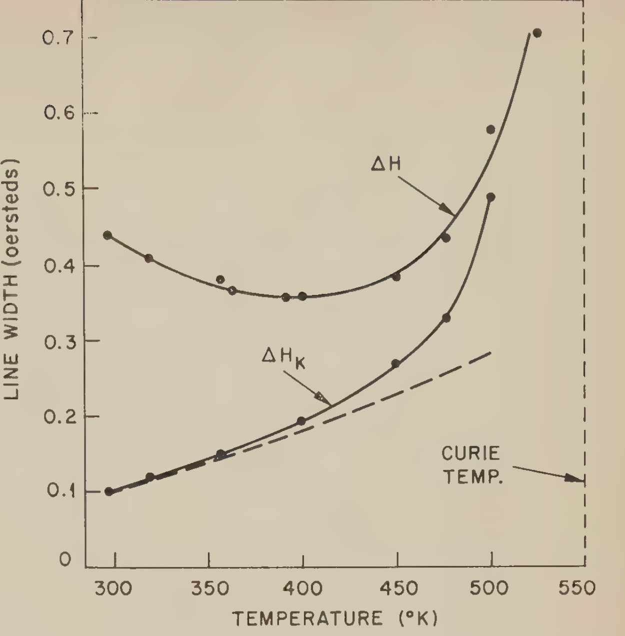


Figure 19 — The line width of the uniform precession ($\triangle H$) and spin waves ($\triangle H_k$) as a function of temperature for YIG at 3330 mc. (After LeCraw and Spencer).

then proposed[53] the use of the nonlinear properties in the construction of a *ferromagnetic amplifier* which was subsequently developed by Weiss.[54] Pulse amplifier performance has been improved and a CW amplifier has now been developed by Denton.[55]

Harmonic Generation.

Both from an historical and pedagogical point of view, the ferrite frequency doubler provides a simple demonstration of the nature of the nonlinear effects in ferrites under conditions of relatively large rf magnetic field intensity. In the expansion of the equation of motion of the magnetization vector.

$$\frac{d\vec{M}}{dt} = \gamma\,(\vec{M} \times \vec{H}) \qquad (10)$$

products of rf quantities may be neglected in the small signal approximation, but these nonlinear terms must be retained for moderately large signal intensity. The magnetic field term, $\vec{H}$, in Equation 10 consists of a static

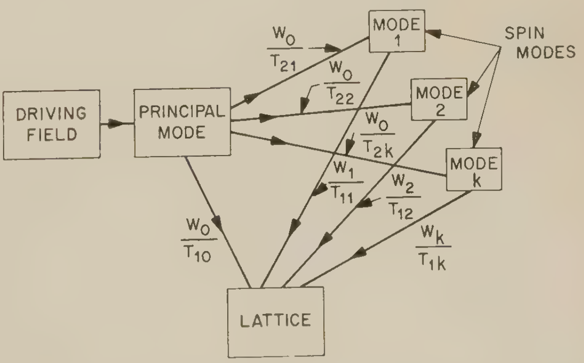


Figure 20 — Schematic diagram of the transfer of energy from the uniform precession of the spins to the lattice both directly and also via the spin wave modes. (After Fletcher, LeCraw and Spencer).

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he spin-lattice relaxation time is the time, on the average, ring which a precessing spin dipole loses energy to the lattice d spirals in toward its equilibrium position in alignment with dc magnetic field.

field and a driving field, $\vec{H}=\vec{H}_o+\vec{h}e^{j\omega t}$, where $\vec{h}$ is smaller than $\vec{H}_o$ but its magnitude cannot be neglected at high signal levels. The magnetization, $\vec{M}$, can be expanded

$$\vec{M}=\vec{M}_o+\vec{m}_1e^{j\omega t}+\vec{m}_2e^{2j\omega t}+\ldots \qquad (11)$$

Assuming $\vec{M}_o$ and $\vec{H}_o$, the static components, to be along the z-direction, and the rf components, particularly $\vec{h}$, to be arbitrarily disposed, then it can be shown that there is an rf z-component of the magnetization

$$(\dot{m}_2)_z=\gamma(m_xh_y-m_yh_x) \qquad (12)$$

composed of the products of the first-order components of $\vec{m}$ and $\vec{h}$. This shows that the nonlinear product of these two first-order components gives rise to a harmonic component of the magnetization provided that the rf field within the ferrite specimen is not circularly polarized. In fact, if either h_x or h_y is zero, the harmonic component is a maximum. This is then the nutational component of the gyration at twice the frequency of the driving field. The amplitude of the harmonic component $(m_2)_z$, can be calculated from Equation 10 when the resonance loss mechanism is included. Stern and Pershan[56] have shown that the amplitude should be inversely proportional to the resonance line width and directly proportional to both the saturation magnetization and the square of the microwave signal intensity. The solution has the form[57]

$$(m_2)_z\approx\omega_Mh_x^2/4\omega(\triangle H) \qquad (13)$$

where $\omega_M=\gamma4\pi M$, ω is the fundamental frequency, h_x is the input magnetic field intensity and $\triangle H$ is the resonance line width. Experiments in the range from 3 kmc to 140 kmc[58] have verified the relation of Equation 13.

Harmonic generators in rectangular waveguide usually employ a ferrite at the side wall or at the center where the rf driving field is nearly linearly polarized. Conversion efficiencies of 3.5 db have been obtained in the X-band region. In the millimeter wave region, peak power output of 50 watts in the second harmonic has been achieved at 140 kmc. Figure 21 shows the relative output vs input power for ferramic G and yttrium-iron garnet,[57] which shows a greater efficiency as the input power is increased. The higher efficiency of YIG is due to its narrower line width.

Saturation Effects.

The early ferromagnetic resonance experiments under conditions of high signal power clearly showed saturation effects in which the susceptibility at resonance declined with increasing power. Classical resonance theory was used initially[48,49] to explain the dependence of susceptibility on applied power according to the expression[59]

$$\frac{\chi''(h)}{\chi''(0)}=\frac{1}{1+\frac{1}{4}\gamma^2h^2T_1T_2} \qquad (14)$$

where $\chi''(0)$ is the small signal susceptibility and T_1 is the spin-lattice relaxation time, defined previously. Th phenomenological relaxation time $T=2/\gamma\triangle H$ is norma ly used for T_2. Although this accounted for some of th features of the saturation effects there remained tw features which were not fully understood: (1) an abru decline in magnetic susceptibility on resonance above characteristic threshold power level; (2) the growth of subsidiary "resonance peak" at a field lower than that r quired for ferromagnetic resonance.

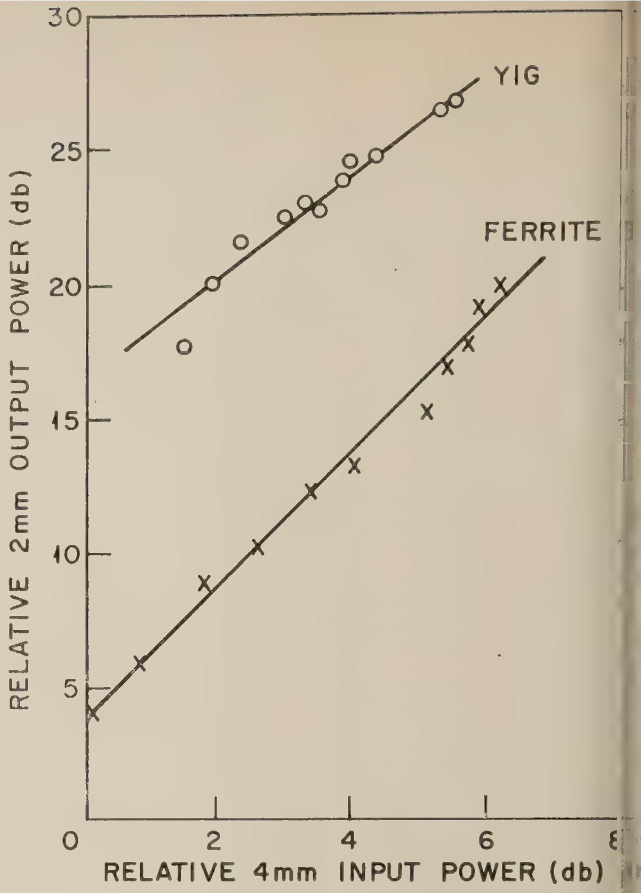


Figure 21 — Input-output curve for frequency-doubling experiment plotted on db scale with arbitrary reference level (After Roberts, Ayres and Vartanian).

Instability Threshold. The basic concepts of the no linear behavior were most clearly developed by Suhl[25,52] his explanation of this seemingly anomalous resonan and abrupt decline in susceptibility at the resonance fr quency in ferrites at high microwave power levels. Th problem was not just that of solving Equation 10 f large signals by retaining second-order terms as in th case of harmonic generation. Actually, it was necessa to explain why the anomalous effects set in at sign levels as much as a hundred times smaller than lar signal theory would predict. This led to the derivation, b Anderson and Suhl[35], of an instability or "run-awa condition of m_z, the rf component of the magnetizatio in the z-direction. In the case of a thin slab magnetiz normally and excited by a transverse, circularly polariz rf field, the Kittel resonance frequency is $\omega_r=\gamma(H_o-4\pi M_z)=\omega_o-\omega_{Mz}$ and the rf susceptibility is $\chi_1=\omega_{Mz}/(\omega_r-\omega+j/T)$ where $\omega_o=\gamma H_o$, T is a phen menological relaxation time, $\omega_{Mz}=(\omega_M^2-\omega_{Mt}^2)^{1/}$ $\omega_M=\gamma4\pi M$ and $\omega_{Mt}=\chi_1\ (\gamma h_t)$. This leads to th solution for ω_{Mz}

$\triangle H \approx \triangle H_k$	Critical Field, h_{crit}	
	Theory	Experiment
51	8	9
46	7	5.5
36	5	4
23	2.5	1
7	0.45	0.55

ble I — Suhl's Comparison of Equation 12 with the Experimental Results of Bloembergen and Wang.

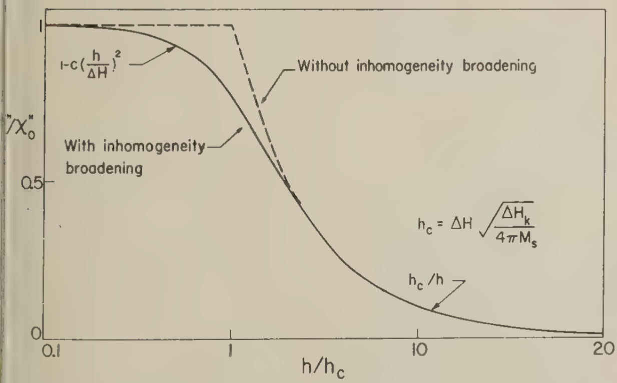
$$ {}_{Mz} = \omega_M \left\{ 1 - \frac{1/2\,(\gamma h)^2}{[\omega - (\omega_o - \omega_{Mz})]^2 + \frac{1}{T^2}} \right\} \qquad (15) $$

om which we can see, by inspection, the nature of the stability. It is the appearance of ω_{Mz} in the resonance nominator that is of importance. A small disturbance in e uniform precession which may cause the precession gle to increase slightly reduces the component m_z. If, r example, the dc magnetic field has been adjusted to a lue somewhat below resonance, this reduction in ω_{Mz} the resonance denominator brings the denominator ser to its minimum value reducing the value of ω_{Mz} Equation 15. If this resulting reduction in m_z is larger an the initial slight reduction in m_z, a run-away con-ion or instability sets in until a new steady-state con-ion is achieved. The condition for instability can be ived by differentiating the right hand side of Equation with respect to M_z, from which Suhl obtains[25]

$$ h_{crit} = \triangle H \sqrt{\frac{3.08\ \triangle H}{4\pi M}} \qquad (16) $$

he role of spin waves must also be taken into account in mputing the critical field intensity, h_{crit}, for the onset saturation of the spin system. We are concerned with e mechanism by which energy can be transferred from e uniform precessional mode into spin wave modes of e same frequency and subsequent transfer of energy to e lattice. This modifies the expression of Equation 16 d leads to a somewhat smaller critical field[52,25]

$$ h_{crit} = \triangle H \sqrt{\frac{2\triangle H_k}{4\pi M}} \qquad (17) $$



gure 22 — Theoretical dependence of the dissipative part of the susceptibility at ferromagnetic resonance on the rf signal intensity. The dashed line illustrates the instability threshold at h_c described by Suhl. The initial decline in the solid line is attributed to the excitation of spin waves at an inhomogeniety in the specimen. (After Schlömann, Saunders and Sirvetz).

where $\triangle H_k$ is the line width of the spin wave resonance. Even for a good single crystal, $\triangle H_k < \triangle H$ in magnitude as shown in Figure 19, but for a polycrystalline specimen, $\triangle H$ is liable to be much larger than the intrinsic line width because of broadening of the main resonance line by anisotropy, stresses and porosity. Thus, saturation of the main resonance is reached at h_{crit} where the uniform precessional angle can no longer be increased by increased driving field intensity because of the loss of energy by the spin system to the lattice, both directly and through the spin waves. Suhl has compared his theoretical results with the early experiments and satisfactory agreement is shown in Table I.

Initial Decline of Susceptibility. Suhl's theory accounted for the abrupt decline in susceptibility at resonance observed in ferrites as shown by the dashed line in Figure 22. More recent theoretical work by Schlömann[60], Suhl[61] and Seiden[62] have led to refinements based on the suggestion by Schlömann that imperfections or inhomogeneities in the crytalline lattice of the specimen can "scatter" the uniform precession into spin waves even at very low rf field intensities, well below the instability threshold, h. In that case, an initial decline in susceptibility on resonance should occur as the field intensity is increased as shown by the solid line in Figure 22. Schlömann[63], Seiden[62] and Weiss[64] have shown experimentally that this is true of imperfect crystals as shown in Figure 23. Thus the transfer of energy to the spin waves increases slowly (except in a perfect crystal) until the catastrophic instability sets in. The expansion of Equation 14 for small values of *h* yields the form of the decline.

$$ \frac{\chi''}{\chi_o''} = 1 - C\left(\frac{h}{\triangle H}\right)^2 \qquad (12) $$

shown by the initial portion of the solid line in Figure 22. Schlömann has proved, however, that the constant C cannot be interpreted with the phenomenological theory and both Schlömann and Seiden have given an analysis in terms of spin wave interaction terms.

Ferromagnetic Amplifier.

In the discussion of the frequency doubler, the nonlinear terms in the equation of motion of a

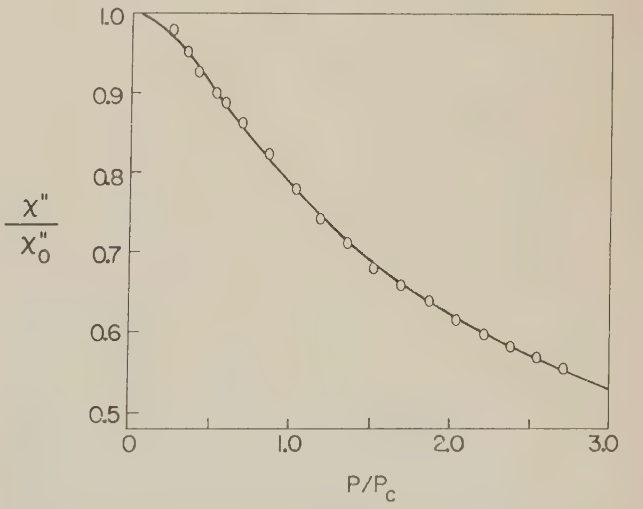


Figure 23 — Experimental dependence of susceptibility at resonance on the rf power level in a ferrite ($Mn_{1.4}Fe_{1.6}O_4$) showing an initial decline due to inhomogenieties. (After Weiss).

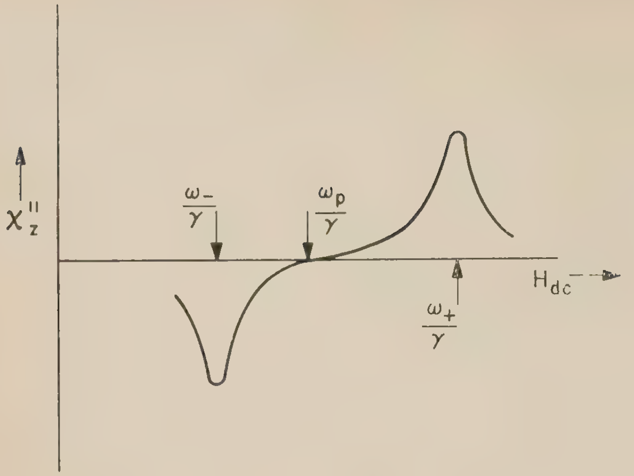


Figure 24 — Dissipative part of the signal susceptibility. (After Berk, Kleinman and Nelson).

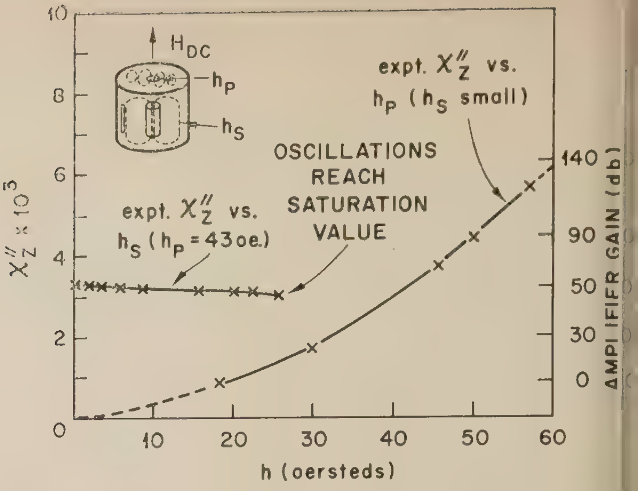


Figure 25 — Variation of negative susceptibility and ga with rf magnetic field intensity at pump (and signa frequencies. (After Whirry and Wang).

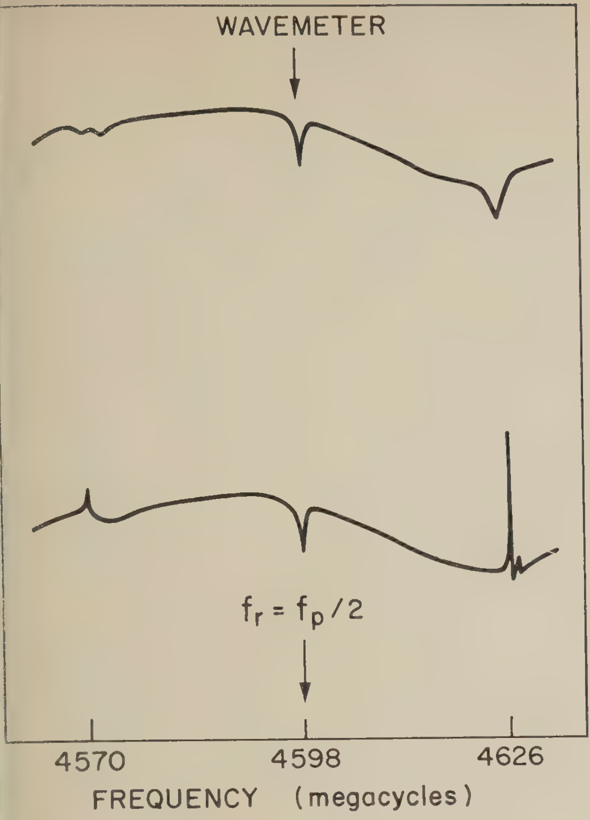
classical spin system have been shown to give rise to harmonic frequency generation. Similarly, incident waves of two different frequencies, properly disposed with respect to the dc magnetic field, will *induce* a magnetic moment, and consequently rf magnetic fields, at the sum and difference frequencies of the two exciting radiations. Therefore, one of the obvious extensions of harmonic generation is nonlinear frequency mixing using ferrites. The most interesting extension of this principle has been the ferromagnetic amplifier proposed by Suhl[53] and subsequently demonstrated by Weiss.[54] However, to get amplification or oscillation (not merely frequency conversion at power levels several magnitudes below that of the source), a feedback system is required. This system must utilize primary energy from an rf pump to provide either gain for a weak signal or spontaneous oscillation for a thermally-induced signal at the desired frequency.

Electromagnetic Operation. Let us consider a system where the rf magnetic field of the high-energy pump at the ferrite resonance frequency, $f_p = f_r$, is applied transverse to the dc magnetic field. The pumping field drives the spin dipoles into a relatively wide-angle uniform precession. Thus all dipoles are precessing in phase and we may imagine a macroscopic magnetization vector precessing about the direction of the applied field, the z-axis. The ferrite is situated in a cavity having two resonant frequencies, f_1 and f_2 where $f_1 + f_2 = f_p$, and where f_1, say, has a magnetic field component along H_{dc} but f_2 has a component perpendicular to H_{dc}. Then a weak "signal" field, h_2, perturbs the uniform precession slightly, introducing an f_2 component in the precession. This induces a second-order contribution to m_z as shown by Equation 12 which radiates into the cavity mode at the difference frequency $f_1 = f_p - f_2$. The induced cavity field h_1, parallel to the z-axis, exerts a torque on the precessing magnetization vector giving rise to radiation into the transverse cavity mode at the difference frequency $f_2 = f_p - f_1$. Thus, the feedback loop has been completed and oscillations can build up at both frequencies f_2 and f_1. External coupling to cavity mode f_2 results in signal amplification, in which case, f_1 is referred to as the idler frequency and f_2 is the signal frequency. This particular configuration is called the *electromagnetic mode of operation* of the ferromagnetic amplifier because it uses tv resonant modes of the cavity for signal and idler fr quencies. Suhl has also proposed the semistatic and ma netostatic modes of operation. The latter uses two ma netostatic modes of the ferrite instead of two cavity mod and the semistatic uses one of each type. A fourth scher has been proposed and demonstrated recently, the mod fied semistatic, in which the idler frequency is equal the resonance frequency of the uniform precessional mo of the ferrite and the pump and signal utilize cav modes. In all cases the sum of two frequencies must equ the third, which is the pump.

The first ferromagnetic amplifier developed by We employed the electromagnetic mode of operation. A though the preliminary amplifier had a gain of 8 db, improved successor[54] using semistatic operation and single crystal of yttrium-iron garnet required only watts of peak pumping power to provide a gain of 25 with a one mc bandwidth. More recently, the modifi semistatic amplifiers have demonstrated gains in excess 100 db.

Modified Semistatic Operation. Berk, Kleinman a Nelson[65], who have described the modified semista amplifier theoretically, used a straightforward analysis the equation of motion of the spin system in the ferr which was analogous to the procedure for a frequen mixer. They assumed a circularly-polarized pump fie much larger in intensity than the signal field and show (Figure 24) that the imaginary (dissipative) part of t signal susceptibility, x_z'', was negative when $\omega_o = \omega$ where $\omega_- = \omega_p - \omega_s$. Therefore, when the dc magne field is biased so that the idler frequency corresponds the uniform precession, the resultant negative susceptibil gives rise to the possibility of amplification at the sig frequency.

Whirry and Wang[66] have demonstrated the operati of the modified semistatic amplifier in a cylindrical cav containing an axially magnetized ferrite rod. A puls circularly-polarized pump field was provided at 8640 using a TM_{120} cavity mode and the signal field was e cited axially at 5930 mc using a TE_{011} cavity mode. T idler frequency was provided by tuning the uniform pr cessional mode to 2710 mc with a dc magnetic field



gure 26 — Resonances of magnetostatic modes in a YIG sphere. The absorptions (upper trace) at 4570 and 4626 mc are observed without pumping. These modes are used for idler and signal frequencies (lower trace) in the CW amplifier using longitudinal pumping at $2f_{res} = 9196$ mc. (After Denton).

10 oersteds. The operating characteristics are shown in igure 25. Since the device has a bandwidth of 1.5 mc, appears to have a gain-bandwidth advantage over a aramagnetic maser amplifier. Moderate noise figures ave been observed and, in one case, Whirry and Wang ave found that at 110 db gain, the noise figure lies be- ween 11 and 16 db.

Longitudinal Pumping. It can be seen from Figure 25 hat large pump power is required to achieve the am- lifier gain characteristics shown. More recent efforts have een directed toward the reduction of pump power re- uirements and CW pumping. The most practical ampli- ier has been developed by Denton[55] utilizing magneto- tatic modes for both the idler and signal frequencies and equiring the relatively low level of 500 milliwatts of umping power. Denton's amplifier employs "longitudinal umping," that is, the rf magnetic field at the pump requency is parallel to the dc magnetic field. This ver- ion of the amplifier can be visualized as the inverse of he frequency doubler since the pump frequency is twice he ferromagnetic resonance frequency. A small sphere f yttrium iron garnet is placed in a cavity which is reso- ant at the pump frequency, 9196 mc, and a dc magnetic ield is applied to tune resonance to 4598 mc establishing the condition $f_{res} = \gamma H_{dc} = f_p/2$. Energy is not actually absorbed at the resonance frequency because there is no cavity mode or other external circuit to support the elec- tromagnetic field at $f_{res} = f_p/2$. Figure 26 shows that two magnetostatic modes, one on either side of resonance, are used as idler and signal frequencies so that $f_i + f_s = f_p$. The upper trace of the figure was taken in the absence of pumping power and shows the wavemeter pip at $f_p/2$ and an absorption on either side due to the magnetostatic modes. Coupling to these modes is made by a loop of wire around the YIG specimen and the loop is attached to an external coaxial line. As the pump power is increased, oscillation occurs in both magnetostatic modes. The system has been made to operate as an amplifier and the emission at $f_s = 4626$ mc is shown in the lower trace of Figure 26. Gain of 25 db has been obtained with a bandwidth of 100 kc and a noise figure of 12 1/2 db.

Gain-Bandwidth. The recent analysis of ferromagnetic amplifier performance by Damon and Eshbach[67] provides a useful comparison of the operating conditions and efficiencies of the several amplifier types. Their derivation of the gain-bandwidth product for the amplifier was based on the determination of the optimum pumping field h which must be large enough to open the precession angle $\theta = h/\triangle H$ to couple the signal and idler modes. They have shown that the maximum gain-bandwidth product can be expressed in terms of the threshold angle θ_{th} as follows

$$g\left(\frac{\triangle\omega}{\omega}\right)_{\max} = \frac{1}{\beta Q_1}\left[\left(\frac{\theta}{\theta_{th}}\right)^2 - 1\right]_{\theta=\theta_c} \qquad (19)$$

where θ_{th} is defined as the minimum value of the precession angle required for amplification, that is, a gain of one. The factor β is of the order unity and Q_1 is the unloaded Q of the signal cavity. The threshold angle depends on the effective filling factor, F, and the Q's of the signal and idler modes

$$\theta_{th} \propto \frac{1}{F_{em}(Q_1 Q_2)^{1/2}} \text{ electromagnetic}$$

$$\theta_{th} \propto \frac{1}{F_{ss}\, Q_1{}^{1/2}}\left(\frac{\triangle H_2}{4\pi M}\right)^{1/2} \text{ semistatic} \qquad (20)$$

$$\theta_{th} \propto \frac{(\triangle H_1 \triangle H_2)^{1/2}}{F_{ms}\,(4\pi M)} \text{ magnetostatic}$$

for the electromagnetic, semistatic or magnetostatic operation respectively. When magnetostatic modes are used, the Q is expressed in terms of line width. Equations 19 and 20 show that a maximum filling factor is required. For electromagnetic operation, the filling factor is just the ratio of specimen volume to cavity volume but is much better for semistatic operation where the factor varies as the square root of this ratio. The most effective operation should be magnetostatic where the filling factor is independent of the ratio and is just less than unity. This latter system was used by Denton whose amplifier required the least power and permitted CW operation.

It is also apparent from Equation 19 that the maximum gain-bandwidth product is obtained for maximum θ. However, θ cannot exceed the critical value $\theta_c = (2\triangle H_k/4\pi M)^{1/2}$ for the onset of instability, where the pump power would be coupled into the spin waves. Thus, it is necessary to choose optimum values of line width, a large $\triangle H_k$ being required for large θ_c but a small $\triangle H$ being required for small θ_{th}. Clearly, if $\theta_{th} > \theta_c$, amplification cannot be achieved. The situation has been summarized by Damon and Eshbach in Table II.

Maximum Voltage Gain Fractional Bandwidth	Mode of Operation
$1/\beta Q_1 \left[\frac{F^2 Q_1 Q_2 4\pi M}{2\omega_1^2/\gamma} \triangle H_k - 1 \right]$	Electromagnetic
$1/\beta Q_1 \left[2F^2 Q_1 \frac{\triangle H_k}{\triangle H_2} - 1 \right]$	Semistatic
$1/\beta Q_1 \left[2F^2 \frac{(\infty \triangle H_k)^2}{\triangle H_1 \triangle H_2} - 1 \right]$	Magnetostatic
$1/\beta Q_1 \left[2F^2 Q_1 \frac{\triangle H_k}{\triangle H} - 1 \right]$	Modified Semistatic

Table II — Gain-bandwidth product derived by Damon and Eshbach for several modes of operation of the ferromagnetic amplifier.

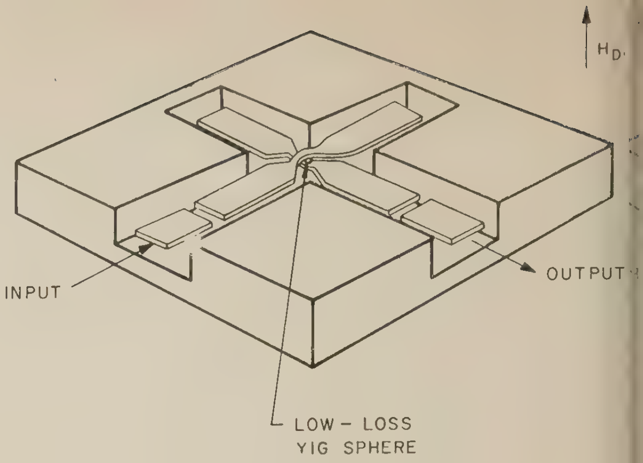


Figure 28 — Crossed stripline cavity with YIG sphere cou ling between lines. The device will act as a power limite reflecting the input pulse, when the coupling is ineffectiv above the critical rf field intensity. (After DeGrasse).

Microwave Power Limiter.

The subsidiary absorption peak arises upon reaching a critical rf field intensity analogous to (but smaller than) that given by Equation 17. This may be used to limit the field intensity transmitted in a waveguide to this critical value. Th waveguide measurements of Sakiotis, Chait and Kal showed that the absorption loss increased sharply as function of peak input power for a dc magnetic biasin field less than that required for resonance, namely, in th region of the subsidiary absorption peak. At low powe levels, the transmission loss is very small. Addition characteristics of the power limiter in rectangular wave guide containing a transversely magnetized ferrite sla have been given by Uebele[68], Skomal and Medina[69], an Martin[70]. The pulse forms shown by Uebele (Figure 27 indicate effective limiting except for an initial spike c 0.1μ sec. duration as well as waveform distortion at th trailing edge. Since the spike has not yet been eliminate the ferrite limiter is not generally used at high powe levels for crystal protection.

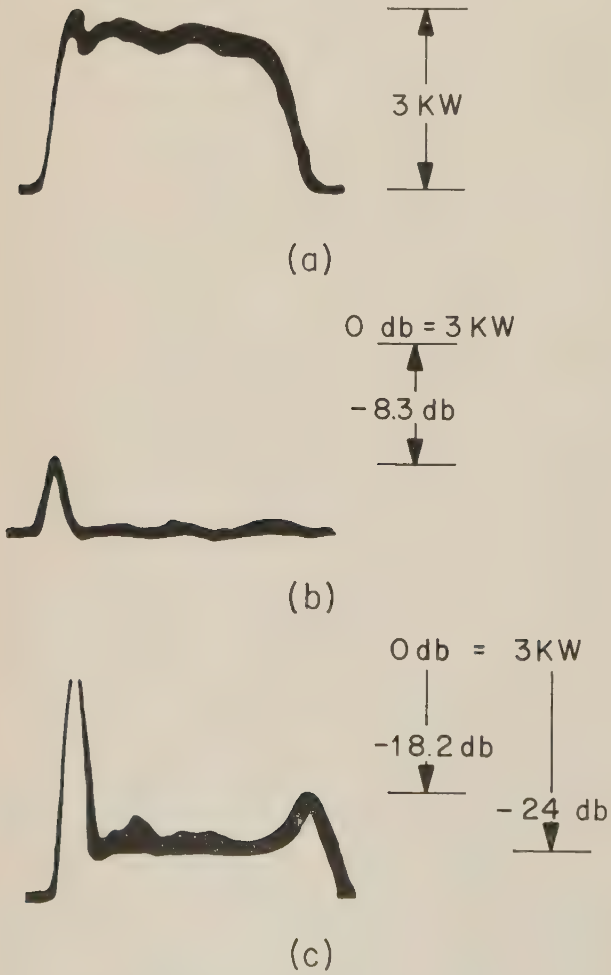


Figure 27 — Microwave power limiter waveforms: (a) input pulse, about 6 μsec. duration, (b) output pulse, (c) output pulse magnified 20 times. (After Uebele).

For medium or lower power applications, DeGrasse[7 has constructed a limiter which operates under the con dition where the resonance of the subsidiary and uniforn precession coincide. At a small threshold power level, th susceptibility collapses. Figure 28 shows crossed stripline strongly coupled at low power level by a sphere of yttrium iron garnet. The coupling becomes negligible at higl power levels where the susceptibility approaches zero an the induced transverse rf magnetic field component coup ling the two rf circuits vanishes. Thus, at high powe the device reflects the input signal.

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Correction

The correct title of the paper by L. Clayton, Jr. and J. S. Hollis appearing in the September, 1960 issue of *the microwave journal* is "Calculation of Microwave Antenna Radiation Patterns by the Fourier Integral Method."

MILLIMETER RADIOMETERS

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Until the recent advent of terrestrially based radio tronomy, our entire knowledge of the universe has been btained through one narrow window (only a single oc-ve in width) in the visible region of the electromagnetic ectrum. Within the past few decades, a much broader indow has been opened and hitherto undetected signals om outside the earth's atmosphere have greatly ineased our store of knowledge. Figure 1 illustrates these mospheric windows. The new window extends from e region of 10 mc/sec to 20,000 mc/sec, or eleven aves in width.

The radio window is limited on the low frequency de by the reflection of the signals from the ionosphere. he high frequency side of the radio window is limited y absorption resonances due to the permanent electricipole moment of the water molecule at approximately 3,000 mc and 190,000 mc, and by spin reorientation esonances in the oxygen molecule near 60,000 and 20,000 mc.

As the practicability of balloon and space vehicle techiques increases, it becomes more feasible to place a eceiver in an environment that is not masked by the tmosphere and ionosphere. Employing this technique liminates the frame of the window through which obervations heretofore have been made.

The character of the detected signals from outer space may be described as either a function of frequency, or as function of direction. One case of a frequency identiied source, is the now classic example of the 1420 mc adiation from interstellar hydrogen. In the case of optical stronomy, there are many examples that exist because a arge number of atomic quantum transitions are possible in the visible region of the spectrum. Observations of arge extended sources, that have discrete frequency characteristics, can be accomplished with relatively non-directional antennas. In the low frequency region, non-directional antennas are the only antennas which can be built to sizes which are practical for use in space. Unfortunately, there are few discrete frequency transitions at the lower frequencies. This is primarily because molecules, and particularly atoms, are tightly bound and cannot be made to undulate with the low energies associated with the lower frequencies.

The character of many signals from extraterrestrial sources may be described as varying as a function of direction. This is somewhat true of the radiation from our own galaxy, but is even more true for each of the many discrete sources (the sun, the moon, the planets, the radio stars, extragalactic galaxies, and colliding galaxies). Some of these targets subtend angles large enough to make scanning for detail an important objective of research.

Millimeter radiometry provides an important tool for the investigation of all signals that are variables as a function of direction. Figure 2 illustrates examples of the narrow, half-power beamwidths which are attainable with antennas of transportable sizes.

For maximum energy transfer, it is desirable to equate the antenna beamwidth to the angle subtended by the target. This maximizes the immersion of the antenna into, what we may think of as, the thermal reservoir of the target. The angular sizes of some of the major targets as seen from the surface of the earth (at closest approach of the planets) are as follows:

Sun	0.532 degrees	Mars	0.007 degrees
Moon	0.492 degrees	Jupiter	0.014 degrees
Venus	0.018 degrees	Saturn	0.006 degrees

It must be noted that the angular size of the target will vary with the range when the radiometer is mounted in a space vehicle capable of appreciably shortening the range over which the observation is to be made. Current space vehicle technology makes it possible to so closely approach the nearer bodies that subtended angles of the order of 50 angular degrees are obtained. It must also be noted that antenna beamwidths, that are appreciably smaller than the subtended angle of the target, are easily

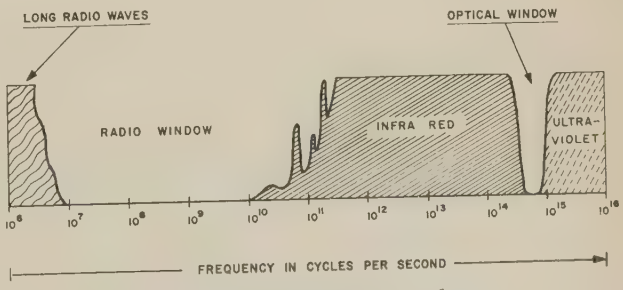

Figure 1 — Atmospheric windows.

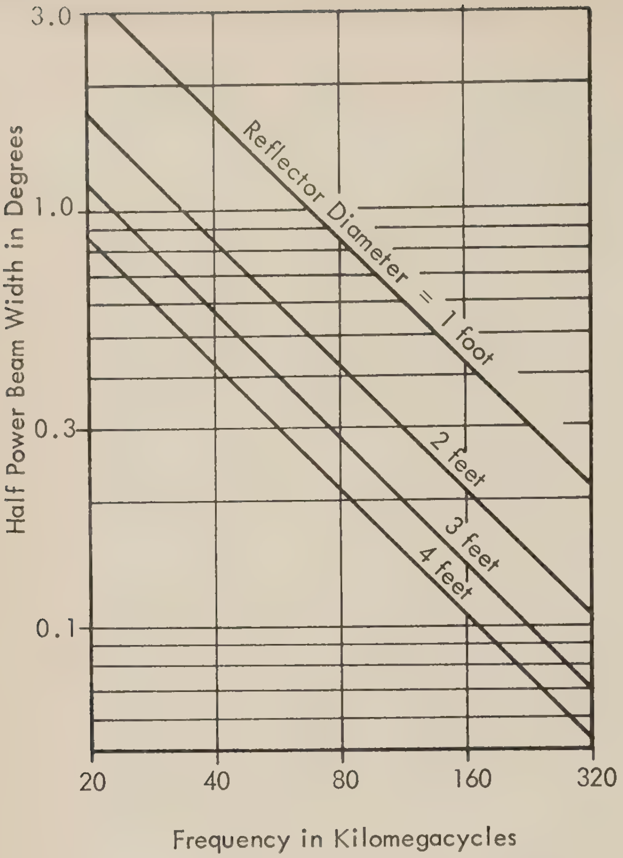

Figure 2 — Beamwidths of millimeter reflectors.

attainable for some of the targets or when the radiometer is space-borne. In these cases, it is possible to probe various regions of the targets, perhaps to study sun spots, solar prominences, or the various surface conditions on the moon.

In the foregoing discussion, we have emphasized the importance of air or space-borne millimeter radiometers to astronomical research and space travel investigations. Additional application of millimeter radiometers can be found in the fields of airborne detection, tracking, and ground mapping.

The principal obstacle in designing radiometers is the need for detection of an extremely small signal. The signal usually is relatively "white" in the optical sense, that is, it has the properties of noise. The signal must be detected from a background field of noise from other sources. As previously mentioned, this may be discriminated by the directional or frequency difference between the signal and the background noise. The background itself may have some directionality, as in the case of angular proximity to the plane of our galaxy. We may also consider other phenomena, such as differential absorption and refraction by varying thicknesses of atmospheric gases, such as is a function of the elevation angle, as being part of the direction varying background noise. The latter of these effects will be eliminated when the radiometer is in the space environment, but the galactic radiation will remain.

Man-made receiving systems contribute an additional noise, as well as providing the gain required to drive an output indicator. The principal method[1] of minimizing this effect is to modulate the signal and to provide a

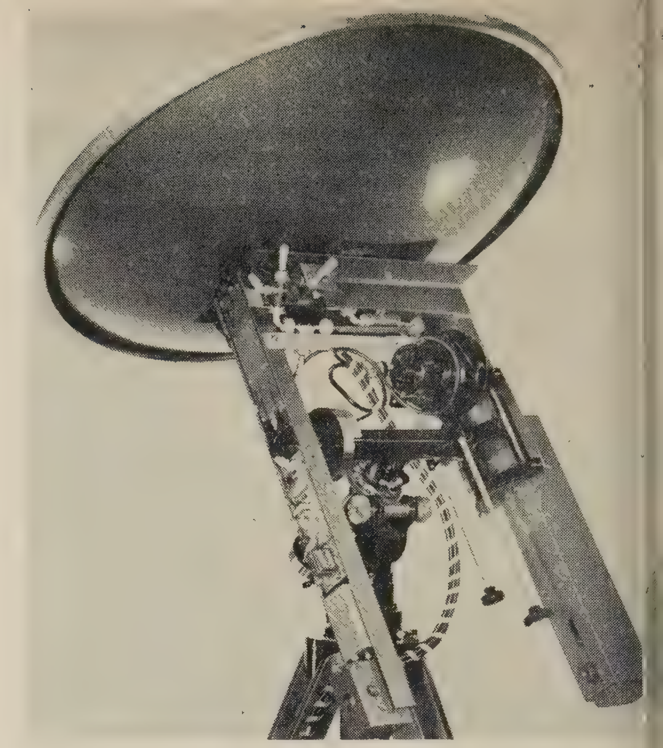

Figure 3 — Millimeter radiometer.

narrow-band, post-detection amplifier tuned to the mod lation frequency.

A prototype millimeter radiometer (Figures 3 and 4 has been designed and assembled for use at 33,000 m This radiometer has many applications. It makes use the "window" in the atmosphere between the water vap and oxygen absorption regions.

Complete transistorization, judicious parts selectio and inherent size advantage of the operating frequenc has resulted in a radiometer of small size and exceller performance. A channel aluminum frame supports the an tenna on a small polar axis mount. All circuits, with th single exception of the local oscillator power suppl are miniaturized and mounted within the channel fram

The antenna assembly consists of a three-foot spu aluminum parabolic reflector, a double-flared feed hor and a length of waveguide to the region behind the verte of the reflector. The reflector has a 47 db gain, a 0. degree beamwidth, and a 12-inch focal length.

The incoming signal from the antenna is square-wav "chopped" at 97 cps by the ferrite modulator. This actio produces a signal that is alternately looking at the tem perature of approximately 290 degrees Kelvin, which i the temperature of the termination built into the modula tor. The modulator driver converts the 97 cps switchin signal from the reference generator into a current squar wave for driving the ferrite modulator.

The incoming signal and the local oscillator signal ar coupled into the mixer through a directional coupler. Th local oscillator is a high beam voltage, low perveance typ reflex klystron. The low noise content of this tube make it possible to use a single diode mixer.

The I-F amplifier is centered at 60 mc with eight m bandwidth, a two db noise figure, and 102 db gain. Th I-F amplifier uses a hybrid type of design, with a ceramic triode in the input stage followed by six silicon transistors

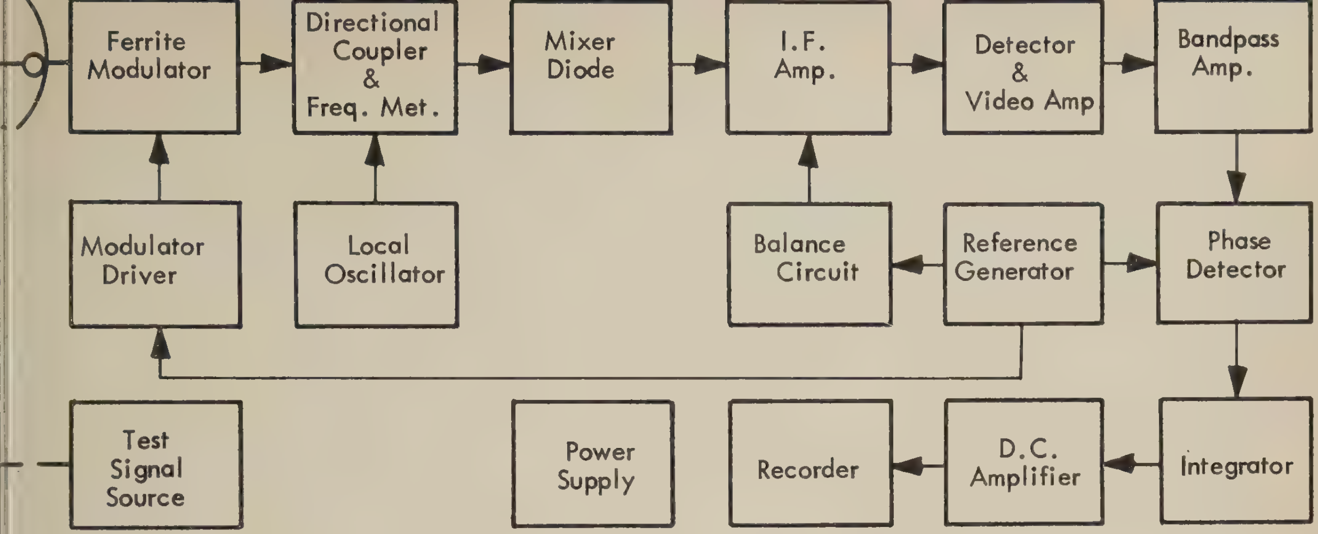

Figure 4 — Block diagram of the millimeter radiometer.

A bandpass amplifier with a center frequency of 97 cps, d a gain of 40 db, follows the detector of the I-F am- ifier. The bandpass amplifier is in turn followed by a opper-type, phase detector.

The output of the phase detector is a pulsating dc gnal which is fed into the integrator. The integrator pro- ies four different RC time constants of 1, 2, 5 and seconds. The output of the integrator is dc amplified d presented to the recorder for display.

Two types of recorders are used: one is intended for oratory measurements and is approximately the size of standard relay rack; the other is intended for field use d is only 100 cubic inches in size and less than four ounds in weight.

The reference generator is a bridge-tee oscillator. Its tput of 97 cps is used by the ferrite driver, the phase etector, and the balance circuit. The balance circuit has e capability of balancing out background noises of 0 to 0,000 degrees Kelvin. Its action is based upon controlled odulation of the gain of the IF amplifier in synchronism ith the modulation of the RF signal by the ferrite odulator. Two types of test signal sources are provided r the calibration of the receiver. The first is a matched rmination at room temperature. This termination may e used alternately with an antenna feed horn, to provide means for comparison with a cold sky. This type of test gnal, when used at the surface of the earth, has a magni- de approximating 300°Kelvin at frequencies having low tmospheric attenuation. At certain other frequencies, otably in the vicinity of 23 and 60 kmc, this difference temperature approaches zero degrees. The other type of test signal source provided comprises a waveguide-mounted, inert-gas, discharge tube and a calibrated attenuator. With this type of source, difference temperatures approximating 10.000° Kelvin are usual. The particular signal magnitude is a function of the gas being ionized, the configuration of the discharge tube relative to the waveguide, the attenuation of the dielectric container of the gas, and the setting of the calibrated attenuator.

Figure 5 shows a recording of the radiometer output as the sun drifts through the beam of the antenna. This observation was made under conditions of light rain. To produce Figure 6, the gain was increased and a baseline fluctuation amplitude was determined. Then the recorder paper was stopped while a matched termination was substituted for the antenna feed horn. After a suitable interval of several time constant's duration, the horn was again replaced and the baseline again observed. Note that there was no appreciable drift. The antenna was then directed at an angle toward the earth. The resultant deflection indicates considerable amount of signal emanating from the earth, but also some spectral reflection of the relatively colder sky.

An analysis of the signal due to the termination as shown in the first plot of Figure 6 is as follows:

The peak to peak signal to noise ratio is observed from the graph to be:

$$M = \frac{33\ \text{divisions}}{1.2\ \text{divisions}} = 27.5$$

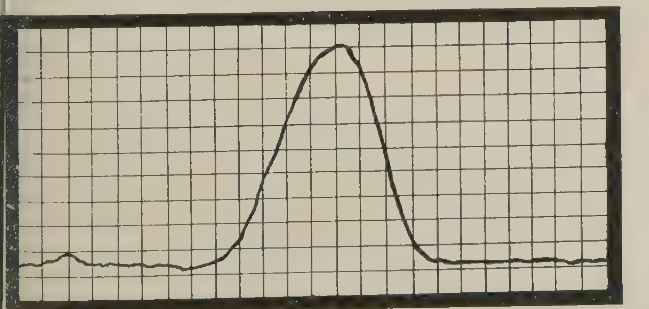

Figure 5 — Sun drift curve.

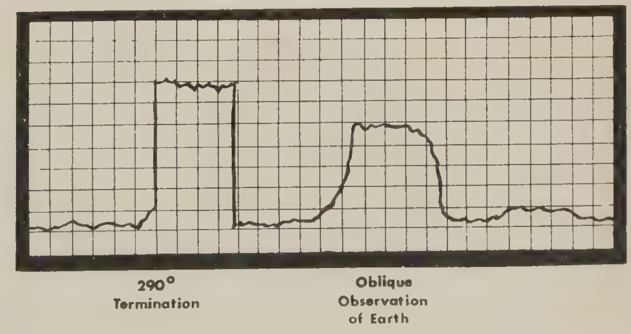

Figure 6 — Termination and earth observation.

The signal is due to the antenna temperature, T_A of the termination and is here equal to 290° Kelvin. If $\triangle T$ is defined as the rms value of the fluctuations, then:

$$M = T_A \; 6 \triangle T \qquad (1)$$

The ratio of the rms to peak to peak values has been equated to six. This follows from an analysis by Rice[2] for the case where 96 per cent of the peak to peak value is attained. This percentage has been found to be pertinent when the recording of the data is of limited duration.

The minimum detectable signal is also equal to $\triangle T$ and neglecting gain variations it has been equated[3] to:

$$\triangle T = K\,(FL-1)\,T/\sqrt{Bt} \qquad (2)$$

where:

K is an empirically determined constant approximately π.

F is the double-channel noise figure of the system.

L is the R-F loss preceding the mixer.

T is the ambient temperature.

B is the bandwidth (in this case of the IF amplifier).

t is the integration network time constant, which can be equated to RC.

Rearrangement of the terms in Equation 1 and solving for the values pertinent to this observation of the matched termination gives:

$$\triangle T = 290/(6 \times 27.5) = 1.76°K$$

Solution of Equation 2 for the noise figure of the system results in:

$$F = \frac{(\triangle T\sqrt{Bt}/\pi T) + 1}{L} \qquad (3)$$

The values of these parameters when this observation was made were:

$\triangle T = 1.76°K$

$T = 290°K$

$t = 10$ seconds

$B = 8$ mc/sec

$L = 3.4$ db

Substitution gives:

$F = 8.4$ or 9.2 db as the system noise figure. This can be improved by the selection of a better mixer.

These results may be used in conjunction with Figure 5 to determine the brightness temperature of the sun. The angle subtended by the sun is 0.532 degrees. The half-power, beamwidth of the antenna is 0.7 degrees. Therefore, the sun fills 0.58 of the area in space subtended by the antenna beam.

$$T_B = T_A/\eta f \qquad (4)$$

where:

T_B = the brightness temperature of the source.

T_A = the antenna temperature of the source.

η = the antenna efficiency (assumed here to be equal to 0.6).

f = the filling factor of the target in the antenna half-power, solid angle.

For the observation of the sun (Figure 5):

$$T_B = 6 \triangle TM/\eta f \cong 6000° \text{Kelvin} \qquad (5$$

This is in reasonably good agreement with publishe values.[4] It is expected than an atmospheric attenuation approximately one-half db was encountered due to th light rain during the observing period.

Prospects for the future of millimeter radiometers a bright. Research is being conducted, to constantly improv these systems, as follows:

1. RF loss has been decreased from 3.4 to 2.0 db, an additional reduction is anticipated.
2. Several of these systems are being scaled to ope ation at different regions of the millimeter spe trum. A superheterodyne type of R-F head fo use in the vicinity of 60,000 to 75,000 mc ha been designed and tested.
3. An investigation of different I-F amplifiers planned. In particular, it is planned to use center frequency of 3,000 mc with 2,000 m bandwidth, a 4 db noise figure, and a 90 db gai
4. Consideration is being given to the use of vide detection and amplification techniques. This ap proach derives its impetus from the need fo lightweight systems and the advantage of elimin ating the local oscillator and its power supply.
5. When broadband, low-noise, traveling wave am plifiers become available, their use will be in vestigated.

In summary, it may be stated that millimeter radio metry will become an increasingly important source o knowledge as space environment is more frequently en countered. This statement is further enhanced by the fac that small, lightweight, millimeter radiometers of high sensitivity have been developed which are adaptable t many forms and varieties as system environment and measurement requirements dictate.

ACKNOWLEDGEMENT

Author appreciation is expressed to Dr. Harold I. Ewe for many enlightening discussions, and to Mr. Hays Pen field and Mr. Stirling Olberg for their contributions t systems design and operation.

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5. Harris, D. B. — "Microwave Radiometry," Microwave Journal volume 3, No. 4, p. 41; April 1960 and volume 3, no. 5 p. 47; May 1960.

CONDUCTING FABRIC ANTENNAS

JAMES W. CURRIE
LEO YOUNG
CHARLES N. GOSNELL

WESTINGHOUSE ELECTRIC CORPORATION
ELECTRONICS DIVISION
Baltimore • Maryland

roduction

The Paraballoon Antenna* is an extremely light- ight, collapsible, radio energy reflector, precisely con- ucted in the form of a shaped, air-inflated balloon from ible coated fabric. It was conceived at Westinghouse 1952, and has since found application principally in dar and communications antennas for tactical military uipment. Here it solves the problem of achieving ge, high-gain reflectors, easily and quickly erected from ht, compact packages which can be economically trans- rted over any terrain.

During the past eight years, eleven prototype anten- s, ranging in aperture size from 14 to 50 feet, have been ilt and completely tested both in the laboratory and in ld use. Production quantities are now being manu- ctured of three of these prototypes.

Many basic development difficulties have been encoun- red and solved. One such problem was that of obtaining d maintaining a high degree of rf reflectivity after re- ated rough handling, creasing, and folding of the flexible ated fabric. This paper presents some aspects of this oblem, and the techniques used in developing the rf flecting fabric.

raballoon Antennas

Figure 1 is a cut-away showing a Paraballoon Antenna t up for operation. This particular rendition is of a 50- ot effective parabolic reflecting aperture system (52 feet verall maximum dimension), enclosed in an air-sup- orted radome of 63 feet equatorial diameter. The inflated ntenna consists of two symmetrical paraboloids of revo- ution constructed from coated, air tight fabric. By ining properly shaped gores of this material, and by djustment of their connecting seams, a close approxima- ion to the desired shape can be achieved, just as the fit of a woman's gored skirt is produced and altered to suit her figure.

One of these paraboloids is constructed of a material which is transparent to rf energy, while the other is treated to make it reflect rf energy. As shown in Figure 2, these two paraboloids are joined at their edges to a large annular tube, also of coated, air-tight fabric, through adjustable, coated-fabric skirts. When the compartment formed by the two paraboloids is inflated to a relatively low pressure (pressures ranging from 0.018 to 0.22 pounds per square inch have been used, depending upon the application), and the air-inflated tube is pressurized to a relatively higher level (10 p.s.i. has been used), a very stiff, stable structure, which serves admirably as a Radar antenna reflector, results.

In order to mount such an antenna on a rotating pedestal for Radar application, it has been truncated at the plane indicated in Figure 2, and attached to a rigid structural base, as shown in Figure 1. The tactical advantages of such an antenna are obvious. The antenna of Figure 1 has an aperture of fifty feet, yet the fabric portions weigh only 991 pounds and, when deflated and properly folded, occupy a transport volume of only 115 cubic feet. Even the lightest of conventional rigid structures to replace this reflector would weigh twice as much, and occupy ten times the transport volume.

Space Antennas

The weight and space advantages of such a structure are even more important for satellite applications. To see how an air-inflated structure can find application in space, where there is no air, substitute the words "pressure-erected" for "air-inflated." The feasibility of pressure-erection by use of bottled gas or expanding vapor has already been demonstrated in the Wallops Island launchings by the National Air and Space Administration. Taking advantage of a limitation of plastics for many applications — the loss of plasticizer over a period of months

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Registered

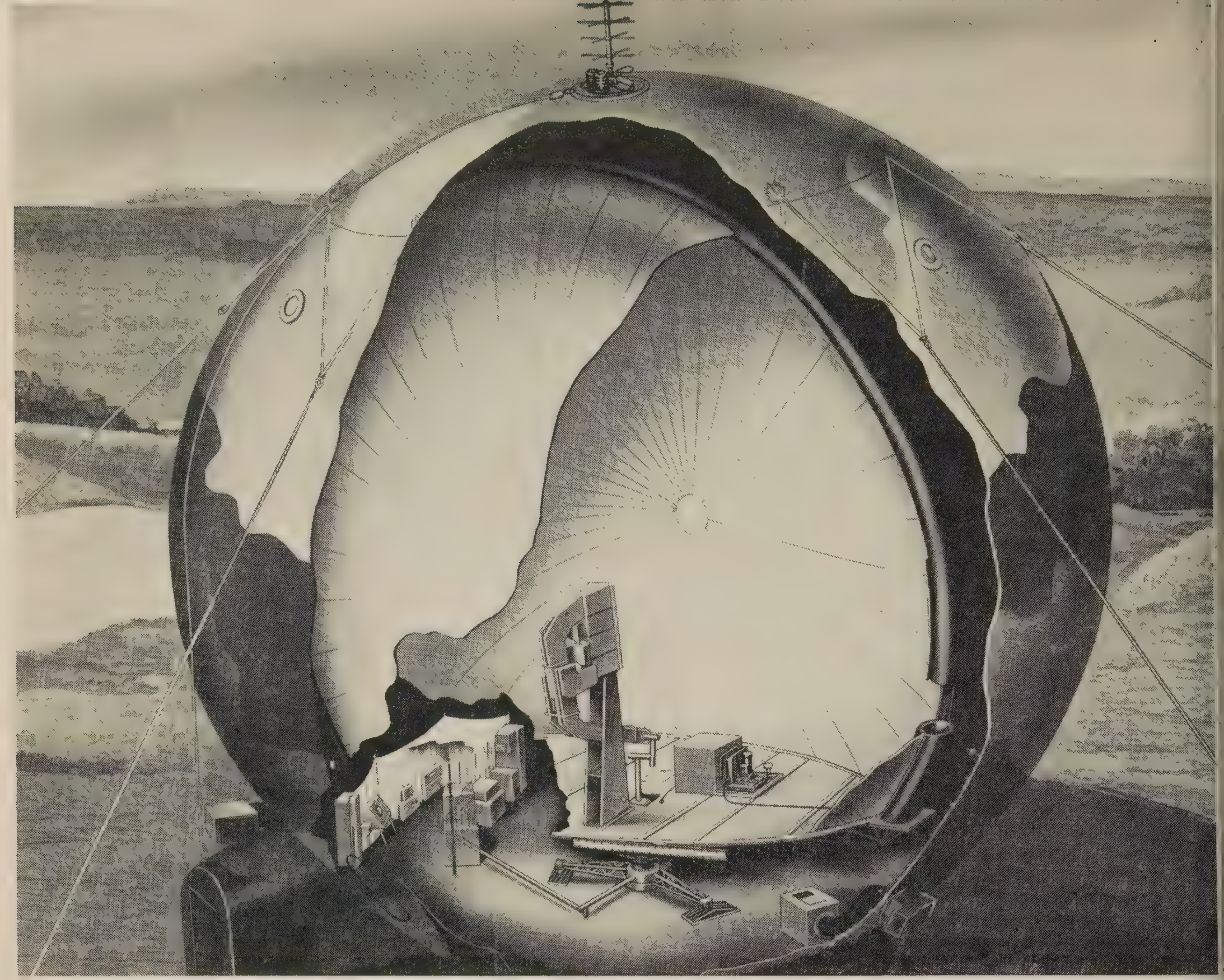


Figure 1 — Cut-away view of a Paraballoon® Antenna.

— we are investigating materials which lose their plasticizing ingredients quite rapidly (in a matter of hours or even of minutes) when exposed to a high vacuum. This loss occurs through evaporation or "boiling off" of the high vapor-pressure plasticizing agents, and leaves a stiff and rigid residue.

This property, which in many applications precludes the use of plastics in space, is highly desirable for this purpose. Thus, the pressure-formed plastic is rigidized and preserved after the pressure has been dissipated. It has been demonstrated that balloon-like structures constructed of extremely thin material and erected and rigidized in this manner retain their geometric shapes quite well when exposed to distorting forces up to one "G." This performance is adequate for most satellite applications in an essentially gravity-free environment where maneuvers are not violent.

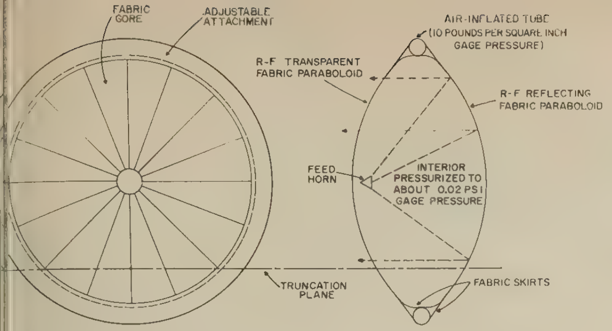
There are many potential applications of metal-coated fabric antennas in various parts of the electromagnetic spectrum. Although experimental work has been mostly on microwave and UHF, other applications are now being developed for pressure-erected or frame supported metallized structures on space vehicles:

1. As Solar Energy Collector, driving auxiliary power units with energy collected from the sun.
2. As infrared reflector, for strategic reconnaissanc and mapping.
3. As Radar Antenna, for long range test target acquisition and observation from earth, lunar an space stations.
4. As Communications Antenna, for world-wide an space communications network.
5. As Solar Sail, for space propulsion, "sailing befor the sun."

RF Measurement Techniques

The two quantities of interest are the reflection an transmission coefficients of the metallized fabric in fre space. The former should be as near unity as possibl and the latter nearly zero. Measurements in free space ar difficult because of interference from surrounding objects Better control is achieved by stretching the reflecting material across a waveguide, so that the radiation is entirel enclosed. A correction must be made for the differen wave-impedances of free space (377 ohms per square and waveguide (Z_w); although this correction would no be necessary if coaxial line were used, the need to ensur good contact around the inner conductor can be avoide by using hollow waveguide measurements.

A typical waveguide arrangement is shown in Figure 3


FABRIC GORE
ADJUSTABLE ATTACHMENT
AIR-INFLATED TUBE (10 POUNDS PER SQUARE INCH GAGE PRESSURE)
R-F TRANSPARENT FABRIC PARABOLOID
R-F REFLECTING FABRIC PARABOLOID
FEED HORN
INTERIOR PRESSURIZED TO ABOUT 0.02 PSI GAGE PRESSURE
TRUNCATION PLANE
FABRIC SKIRTS

ure 2 — Basic construction of the first Paraballoon® Antenna.

The equivalent waveguide termination is the wave im-dance, Z_w, of the waveguide in parallel with the im-dance per square, Z, of the conducting fabric. If the nple is resistive, so that its impedance is measured in l ohms per square, and if further the conducting layer ckness is small compared to the skin depth, then the resistivities (ohms per square) should be equal. In ctice, dc resistivities have usually run about half those asured at rf.

The TE_{01} mode in rectangular waveguide has been ployed, so that

$$Z_w = 120\pi\lambda_g/\lambda \text{ ohms per square} \quad (1)$$

ere λ is the free space wavelength and λ_g the guide velength. With λ_g/λ usually around 1.4,

$$Z_w = 530 \text{ ohms per square.} \quad (2)$$

It is convenient to measure the high VSWR set up by e near short circuit of the material to determine both re-cted and transmitted power. The transmitted or leak-e power can be deduced from the VSWR only if it is own how much power is absorbed in the resistive com-nent of the fabric.

It is further necessary to convert the VSWR measured waveguide, V_w, to the VSWR which exists in free ace, V_s.

RF tests have shown that the materials are almost urely resistive, the impedance per square being a real uantity, the resistivity r. It can easily be shown that for urely resistive materials,

$$V_s = 1 - (\lambda/\lambda g) + (\quad \lambda g)\ V_w \quad (3)$$

hich for high VSWR reduces to

$$V_s = (\lambda/\lambda_g)\ V_w \quad (4)$$

hus less power is reflected in free space than in wave-guide. The resistivity, r, of the material, when the VSWR is high, is given by

$$r = (Z_w/V_w) = 120\pi/V_s \quad (5)$$

The leakage power in waveguide for high VSWR is

$$P_w = 4/V_w^2 \quad (6)$$

and in free space

$$P_s = 4/V_s^2 = 4(\lambda_g/\lambda)^2/V_w^2 \quad (7)$$

For instance if the VSWR in waveguide after correction for the waveguide attenuation between the material and the slotted line probe is $V_w = 200$ (46 db), then with $\lambda_g/\lambda = 1.4$, $V_s = 142$, or 43 db; and $P_s = 2 \times 10^{-4}$, or -37 db.

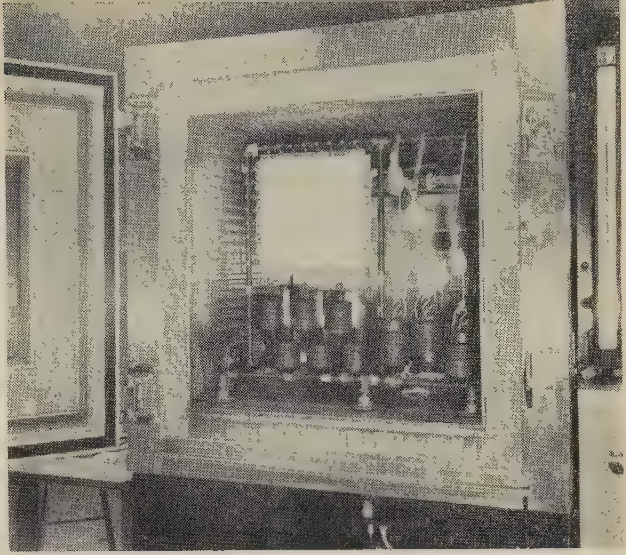


Figure 4 — Environmental box with fabric under stretch test.

Experimental Results

The early fabrics had vapor-deposited aluminum on mylar film added for the conducting layer, but although good reflectivities were obtained initially, this did not stand up to repeated handling and folding, although the surfaces remained shiny as judged by the human eye.

Vinyl resin with silver pigment dispersed in it when spread-coated and fused on fabric under carefully controlled and monitored conditions yielded a conducting silver pigmented vinyl layer with the desired properties. It has stood the test of time and various forms of abuse to which it is subjected in the laboratory (Figure 4) and in the field. Measurements have been carried out from

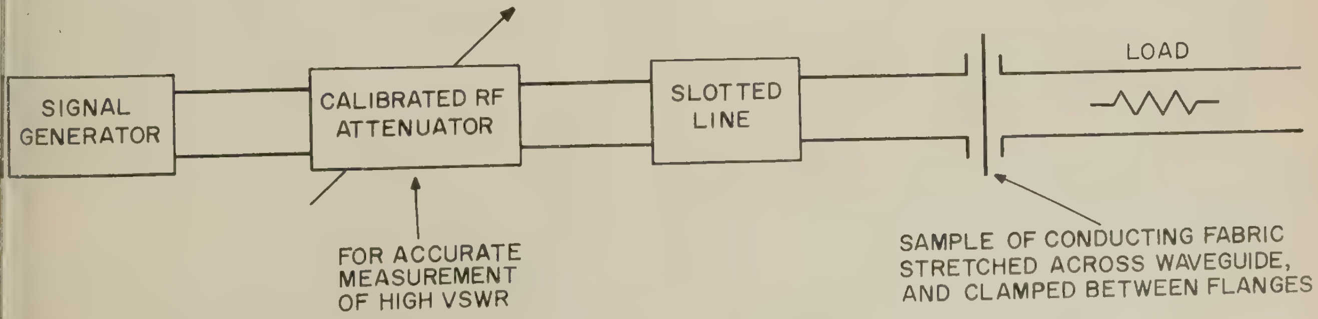

SIGNAL GENERATOR
CALIBRATED RF ATTENUATOR
SLOTTED LINE
LOAD
FOR ACCURATE MEASUREMENT OF HIGH VSWR
SAMPLE OF CONDUCTING FABRIC STRETCHED ACROSS WAVEGUIDE, AND CLAMPED BETWEEN FLANGES

Figure 3 — Waveguide arrangement for testing reflectivity of fabric.

X-band to UHF, but mostly at 1000 mc. VSWR's (V_w) were generally between 50 and 56 db (with a well fitted metal plate they are about 60 db), i.e. between 316 and 633. Using equation (5) with $Z_w = 530$ ohms per square, this yields rf resistivities of 0.84 to 1.68 ohms per square. Measurements made at dc on the same batch of conducting screens yielded values of 0.2 to 0.8 ohms per square. The difference between the measured dc and rf resistivities can be accounted for partly by the difficulty of making good contact between the conducting screen, or even a metal plate, and the waveguide; and partly by the fact that the depth of the conducting layer is only of the order of the skin depth.

Conclusion

Pressure erected or frame-supported fabric screen antennas have already been shown to be practical for ground based radar and communication antennas wh weight, transportability, and erection time are at a p mium. With the advent of the space age, there are li ly to be many more applications, some of which are n being actively explored at the Westinghouse Electron Division.

Acknowledgement

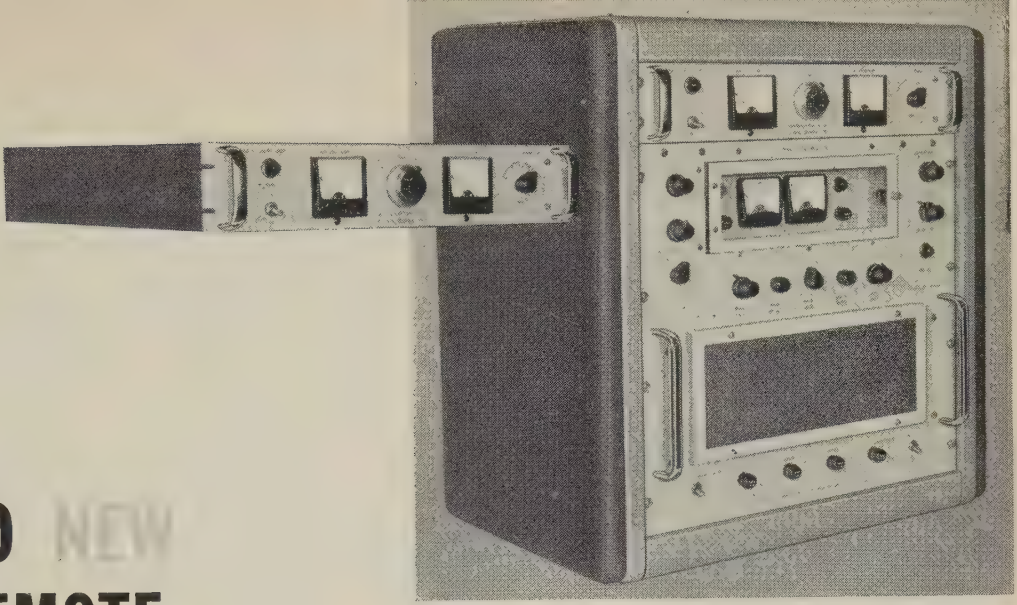
The authors wish to acknowledge the contributions Mr. S. H. Saulson to the development of the Paraballo Antenna which first utilized this reflective coating.

Note

For further information and photographs, the followi publications may be consulted:

Aviation Week, Vol. 65, No. 17, October 22, 1956, pp. 94-

Life, November 5. 1956, pp. 111-114.



Model SS 20 Signal Source Power Supply with Tuning Unit. Tuning Unit is removed to control position for remote operation. Inset shows unit removed for remote operation. In this mode, control unit can be operated up to one mile away.

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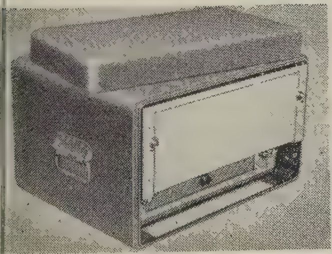
Power Output	80 mw into 50-ohm load	see table of RFO Oscillators

SERIES RFO OSCILLATOR UNITS

MODEL	FREQUENCY RANGE	OUTPUT POWER
RFO 1	1.0 - 2.0 kmc	40 - 800 mw
RFO 2	2.0 - 4.0 kmc	100 - 800 mw
RFO 3.6	3.6 - 7.2 kmc	5 - 300 mw
RFO 7	7.0 - 11 kmc	20 - 300 mw
RFO 8.5	8.5 - 16 kmc	5 - 100 mw
RFO 15.5	15.5 - 24 kmc	5 - 125 mw
RFO 23.5	23.5 - 37.5 kmc	5 - 100 mw



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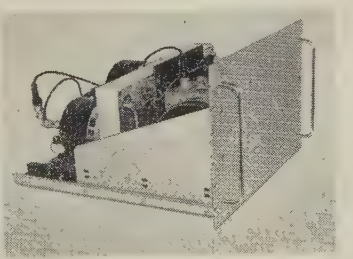

Model SS 30 RF Oscillator Unit

PRICES

Model SS 30, $3,850; SS 20, $3,550; SSG 1 Sine-Square Wave Generator, $350; RFO 1, 2 and 3.6, $1,400; RFO 7, $1,900; RFO 8.5, $2,060; RFO 16, $3,330; RFO 23.5, $3,330. For more details, please contact your S-A representative or write directly. Address Dept. 69

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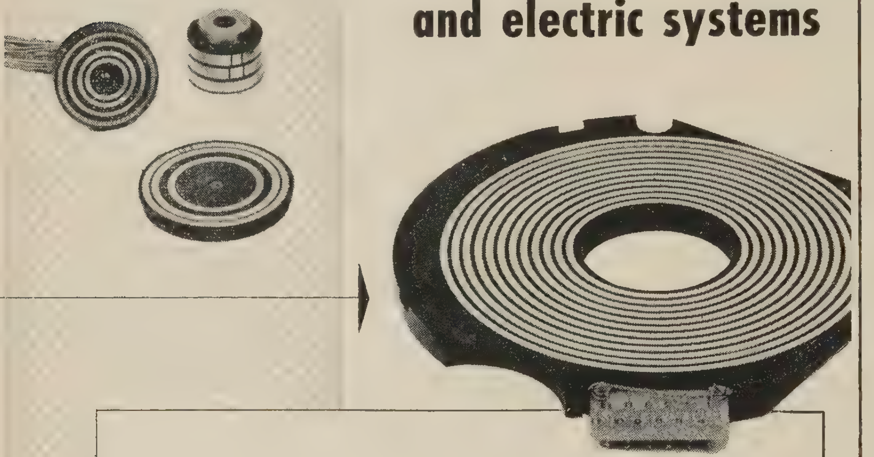

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Industry News

(*Continued from page 43*)

HUGHES PROGRAM AIDS COUNSELORS TO ADVISE YOUT

A training-in-industry program f high school counselors was conducted Hughes Aircraft Company's ground sy tems plant at Fullerton, Cal. this sum mer as one step toward meeting the n tion's future needs for more scientists a engineers.

Two counselors, George L. Olds Orange (Cal.) High School and Samu H. Ortiz of Santa Fe Springs (Cal High School, spent four weeks at t Hughes plant under Claremont Colle graduate school's "scholarships in c cupational guidance" program.

"America's future needs for scientis and engineers may be met by increas cooperation of industry and education Phil N. Scheid, Hughes personnel ma ager, said. "By learning at first hand t electronic industry's personnel requir ments and standards, high school cou selors will be better able to advise you in setting realistic job goals and makin long range career plans."

—*mwj*—

SPERRY ANNOUNCES NEW ELECTRONIC AMPLIFIER

Development of a new electronic am plifier, to be among radar's most powe ful microwave transmitter tubes, h been undertaken for the U.S. Army Si nal Corps, Sperry Gyroscope Co., Gre Neck, N.Y., has announced.

The new device, a super-power kl stron, will be available for use wit NIKE ZEUS, the Army's anti-missi defense system now being developed b the Western Electric Co. It will exten future radars into the next higher lev of super-power, which will be enoug to serve as a basis for new types electronic weapon systems.

"With the higher power klystron, w can make radars perform new tricks f better detection of distant, fast-movin targets," Army scientists said.

The new development is being a celerated under an initial contract f $1.3 million. Twenty additional developmental models of the new tub will be built for use in development new types of radars. About $350,000 i the initial development is being subcontracted immediately to small busines firms for construction of special purpos test equipment for experimental oper tion of the new klystron. This include a 100-ton, high voltage unit about th size of a small ranch house (30 x 4 feet), for testing the new klystron.

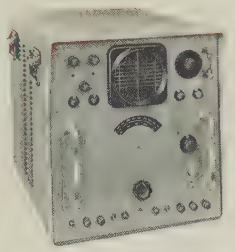
Initial design of the super-power klystron has already been pushed to completion through use of special electroni computer techniques devised by Dr. C. C Wang, Sperry scientist. The compute mathematically constructs and tests experimental models of the tubes befor they are built. In this way, experimenta work that previously required months o

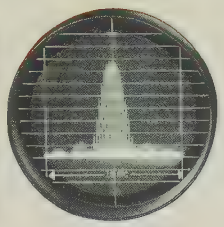
(*Continued on page* 76)

VISUAL MICROWAVE ANALYSIS 10 to 44,000 mc

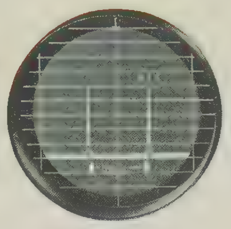
DEL TSA
ECT-READING
CTRUM ANALYZER

to 44,000 mc with
e plug-in tuning
its

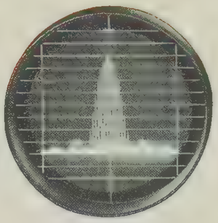




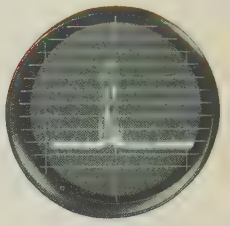
0.4 μSEC PULSE



STANDARD SIGNAL



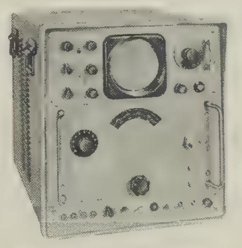
DECODED MULTIPULSE SPECTRUM

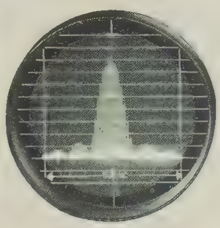


INCIDENTAL FM ANALYSIS

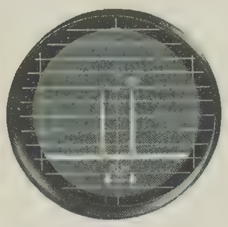
DEL TSA-S
MBINATION
NCHROSCOPE-
ECTRUM ANALYZER

to 44,000 mc with
e plug-in tuning
its

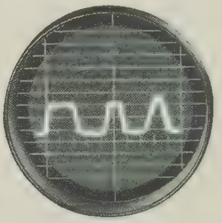




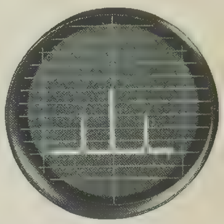
10 μSEC PULSE



STANDARD SIGNAL



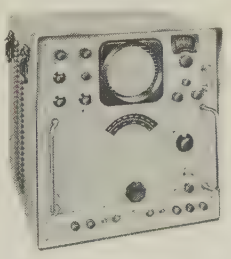
ANALYSIS AS A FUNCTION OF TIME

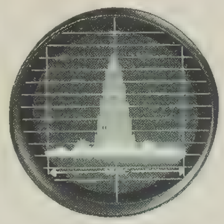


IDENTIFICATION OF AMPLITUDE MODULATI

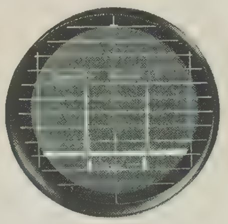
DEL TSA-W
DE DISPERSION
CTRUM ANALYZER

to 44,000 mc with
plug-in tuning
s—70 mc disper-

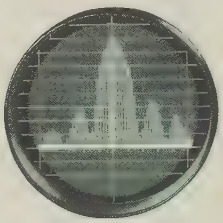




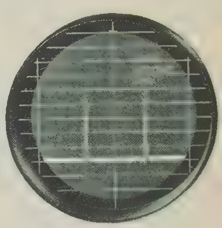
0.1 μSEC PULSE



AFC ACTION



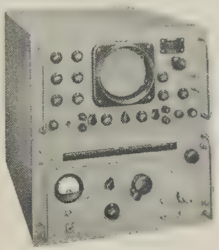
LOG DISPLAY

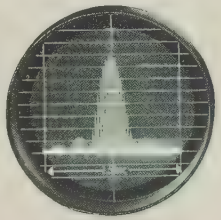


SIGNAL STABILITY MEASUREMENT

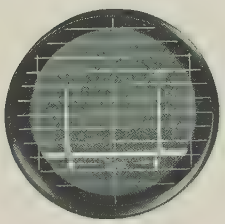
DEL SA-84
VERSAL SPECTRUM
ALYZER

to 44,000 mc in
e integrated self-
ntained unit

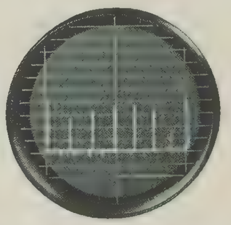




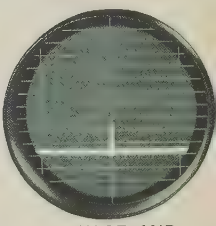
4 μSEC PULSE



STANDARD SIGNAL



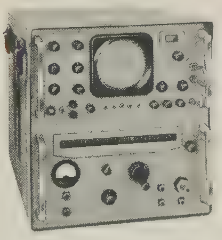
FM SIGNAL ANALYSIS

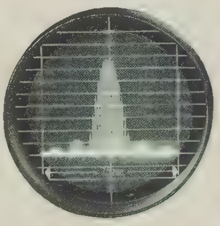


LEAKAGE AND RADIATION MEASUREME

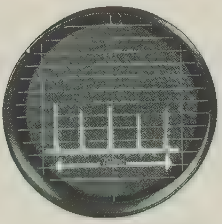
DEL SA-84W
DE DISPERSION
IVERSAL SPECTRUM
ALYZER

to 44,000 mc in
e integrated self-
ntained unit—fea-
res over 80 mc dis-
rsion

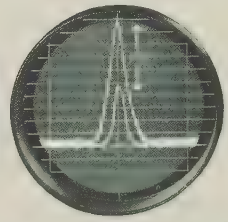




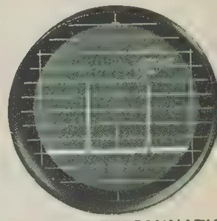
0.08 μSEC PULSE



CRYSTAL HARMONICS



PRECISION ATTENUATION



ACCURATE DETERMINATI OF FREQUENCY

The scope displays shown opposite each Polarad pectrum Analyzer serve two basic purposes—first, they ustrate the significant analysis capability of each strument; second, they demonstrate the many microave parameters that can be measured and displayed sually, on Polarad's versatile analyzing equipment.

FREE LIFETIME SERVICE

MAIL THIS CARD for specifications. Ask your nearest Polarad representative (in the Yellow Pages) for "Handbook of Spectrum Analyzer Techniques."

OLARAD
LECTRONICS
ORPORATION
-20 34th Street, Long Island City 1, N.Y.
epresentatives in principal cities.

© P.E.C.

POLARAD ELECTRONICS CORPORATION: 1234567

Please send me information and specifications on:

☐ Model TSA
☐ Model TSA-S
☐ Model TSA-W
☐ Model SA-84
☐ Model SA-84W
☐ Model SD-1
(see reverse side)

POLARA

My application is__________

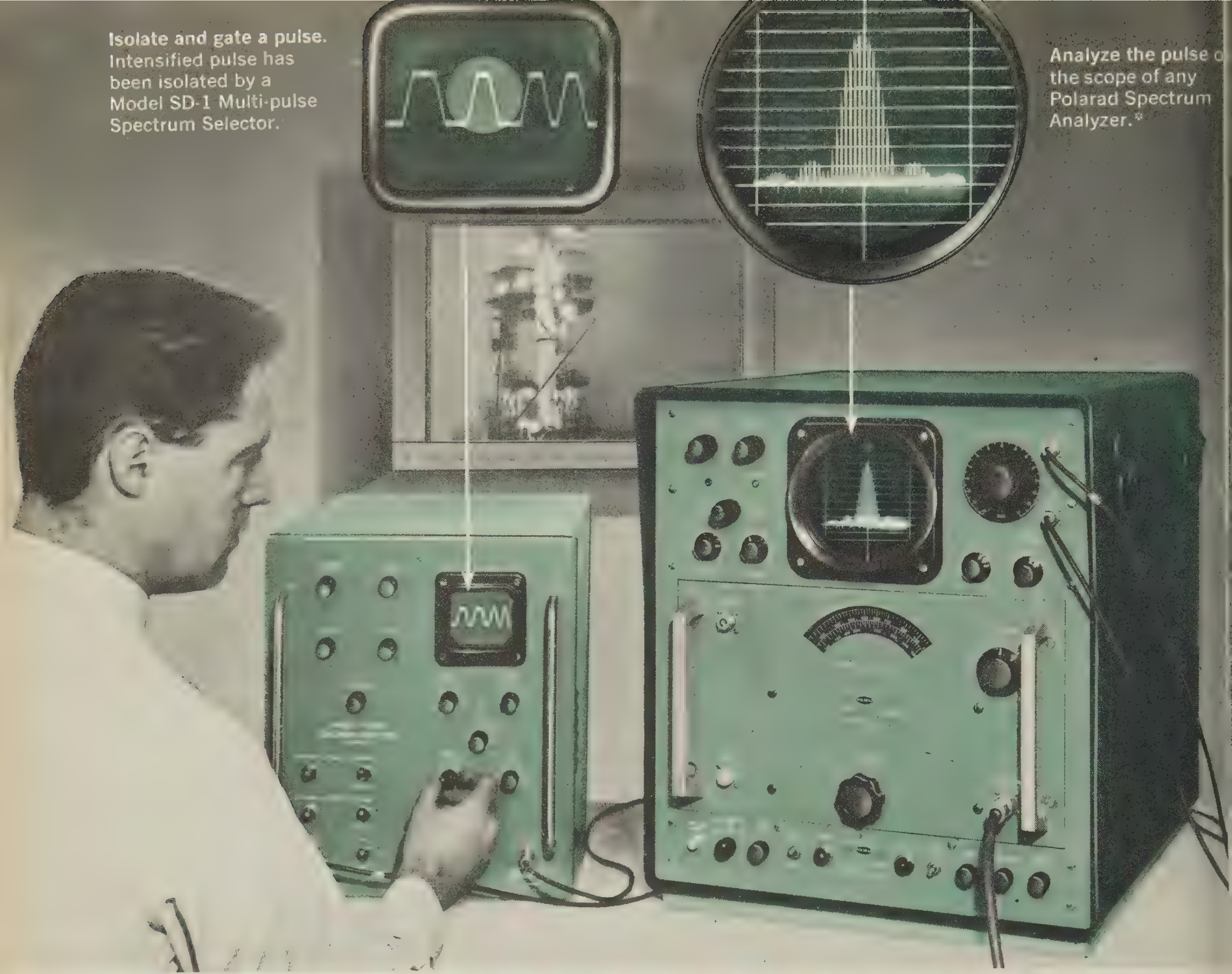
Name__________

Title__________ Dept.__________

Company__________

Address__________

City__________ Zone_____ State_____



Isolate and gate a pulse. Intensified pulse has been isolated by a Model SD-1 Multi-pulse Spectrum Selector.

Analyze the pulse o the scope of any Polarad Spectrum Analyzer.*

COMPLEX SPECTRUM DECODING

10 to 44,000 mc.

Signal Analysis for Missiles, Telemetry, IFF, Beacons and Radar

The Polarad spectrum selector permits spectrum analysis and decoding of any selected pulse within a multiple pulse train. Sweep, gate width and position can be controlled. Model SD-1 permits the selection and gating of a group of pulses up to 180 μsec. in length (Model SD-IX permits 350 μsec.)

Works with POLARAD Models TSA, TSA-S, TSA-W, SA-84 and SA-84W spectrum analyzers.

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BUSINESS REPLY CARD
First Class Permit No. 18, Long Island City 1, N.Y.

POLARAD ELECTRONICS CORP
43-20 34th St., Long Island City 1, N. Y.

POLARAD

MAIL THIS CARD for specifications. Ask your nearest Polarad representative (in the Yellow Pages) for a copy of "Notes on Microwave Measurements."

FREE LIFETIME SERVICE
ON ALL POLARAD
INSTRUMENTS

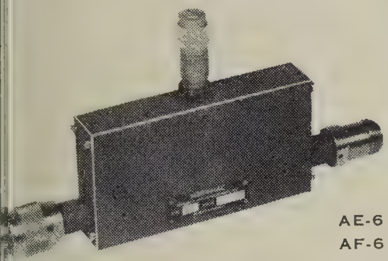
POLARAD
ELECTRONICS
CORPORATION

43-20 34th Street, Long Island City 1, N.Y.
Representatives in principal cities.

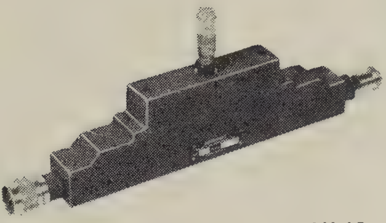
UNIQUE **Merrimac** COAXIAL DEVICES

ZERO LOSS CONTINUOUSLY VARIABLE COAXIAL ATTENUATORS*

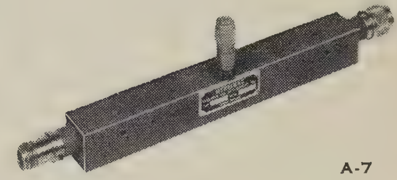
* PATENT PENDING



AE-6
AF-6



AU-10



A-7
A-10

Constant attenuation at any level over broad frequency bands . . . Flat from 4 to 8 kmc and 8 to 12.4 kmc. Average power rating of 4 watts.

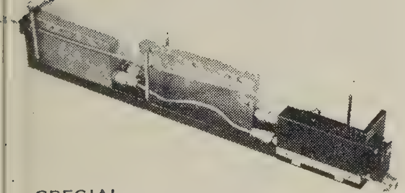
HIGH POWER

— 300 to 5000 mc range —
up to 60 db range.

Provides up to 60 db of attenuation range in the 1-7 kmc band. Two watts average power. Moderately priced.

These attenuators may be modified to suit your particular applications.

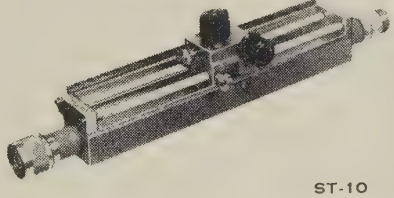
OTHER NOVEL MERRIMAC DEVICES



SPECIAL

This special air-borne assembly illustrates our capacity in designing, developing, packaging and producing microwave sub-systems.

The device illustrated has a broadband flat variable attenuator, flat directional coupler and two band-pass filters with 20% pass bands.



ST-10

Slide Screw tuner in coaxial configuration . . . for use over the 1 to 8 kmc band . . . provides smooth tuning over the entire Smith Chart.

Merrimac Microwave components and subsystems cover extremely broad frequency bands. The advanced performance characteristics of these devices are unique to Merrimac products — they are not available elsewhere.

Merrimac
RESEARCH AND DEVELOPMENT, INC.

517 Lyons Avenue
Irvington, New Jersey
ESsex 1-1616

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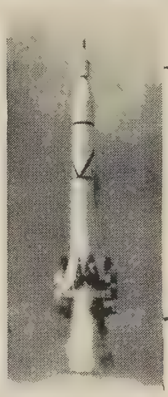
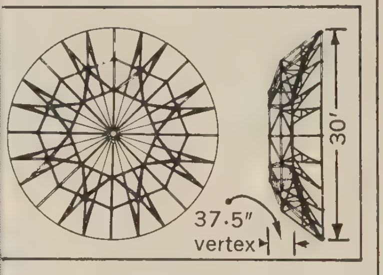




This precision 30-foot antenna has a more accurate surface than any other production parabolic reflector of comparable size.

Antenna System's new solid surface, high precision 30-foot antenna (model 103) is designed to set a new standard for accuracy in the fields of radio astronomy, tropospheric scatter propagation, tracking radar, and experimental test installations. It features:

- High precision — The static surface tolerance of the first unit has been measured. The deviation from the ideal curve measured 0.033 inches RMS.
- Has an f/d ratio of 0.417 which readily adapts to a wide variety of feed systems.
- Fully machined sections are interchangeable and easy to assemble.
- Solid surface panels permit use at any frequency.
- Useable with a wide variety of feed support systems.
- Built to withstand 150 MPH wind with 4" ice.
- Can be mounted on either the top or side of a tower with azimuth and elevation adjustments, on el-az or equatorial pedestals, self-contained trailer tower mounts, or other types of mounts.

Write for specification sheet.

DESIGNERS AND MANUFACTURERS OF ANTENNA SYSTEMS

ANTENNA SYSTEMS INC. HINGHAM, MASSACHUSETTS

Circle Reader Service Card 42

Industry News

(*Continued from page 72*)

trial and error in the laboratory is nc
accomplished with exactness in a f
days in the Sperry Electronic tube
cility.

The super-power tube project is one
a number of advanced klystron develo
ments being conducted under the g
dance of Army scientists in the Micr
wave Tubes Branch of the U.S. Arr
Signal Research and Development Labo
atory, Fort Monmouth, N.J. Scienti
advisor to the project is Army scient
Dr. G. Pokorny. The development wo
is under the direction of T. D. Seg
chief high-power klystron engineer
Sperry's electronic tube laboratories
Great Neck, N.Y.

—*mwj*—

CWS WAVEGUIDE ELECTS NEW BOARD MEMBER

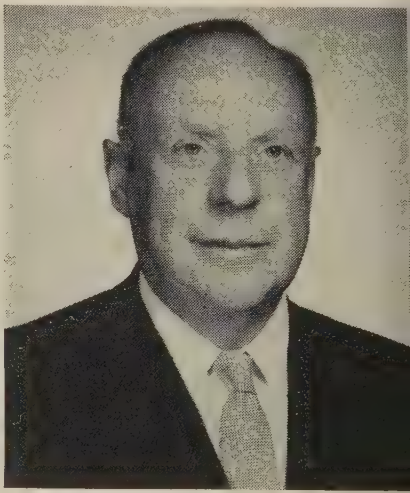
Mr. Herbert K. Allard has been elect
to the Board of Directors of CWS Wav
guide Corp., Lindenhurst, Long Islan
microwave firm.

Mr. Allard is president of H. K. Alla
& Associates of Cambridge, Mass., Ma
agement Consultants and Industrial Eng
neers to the Electronics industry. His fir
recently completed a study and analys
of overall production operations f
CWS Waveguide Corporation.

—*mwj*—

ANDERSON MOVES UP AT FXR, FELDMANN BOARD CHAIRMAN

Tore N. Anderson, executive vi
president of FXR, Inc., of Woodsid
N. Y., manufacturer of microwave te
instruments and associated equipment, h

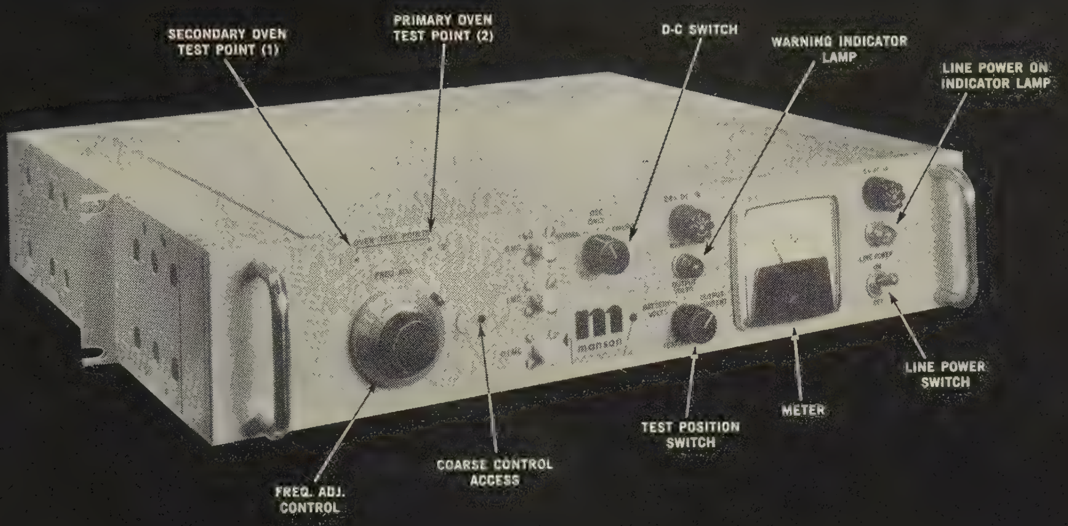


Henry Feldmann

been named president of the firm. H
succeeds Henry Feldmann, the founde
who moves into the newly created po
of board chairman.

Mr. Anderson, formerly vice preside
and director of engineering at Airtro
Inc., a division of Litton Industrie
came to FXR last January as assistant
the president. He became executive vi

(*Continued on page 78*)


SECONDARY OVEN TEST POINT (1)
PRIMARY OVEN TEST POINT (2)
D-C SWITCH
WARNING INDICATOR LAMP
LINE POWER ON INDICATOR LAMP
LINE POWER SWITCH
METER
TEST POSITION SWITCH
COARSE CONTROL ACCESS
FREQ. ADJ. CONTROL

New, Transistorized, Low-Cost

FREQUENCY STANDARD by MANSON!

STABILITY

±5 PARTS IN

10^{10}

PER DAY

5 MC, 1 MC and 100 KC HIGH STABILITY FREQUENCY STANDARD, Model RD-180

- **Output Frequencies:** 5 Mc, 1 Mc, and 100 kc.
- **1 Mc and 100 kc (simultaneous) Output Levels:** 1 volt rms +50/−10%.
- **5 Mc Output Level:** 25 mv./into 1K ohm load.
- **Output Impedance:** 1 Mc & 100 kc into 50 ohms.
- **Ambient Temperature Range:** 0°C to 50°C.
- **Ambient Humidity Range:** 0 to 95% RH.
- **Warm-up Period:** 6 hours.
- **Frequency Stability (after 4-month aging) under following conditions:**
    1. ±5 parts in 10^{10} per day.
    2. 25°C Ambient ±25°C: ±5 parts in 10^{10}.
    3. ±20% Change in 50-Ohm Load: ±2 parts in 10^{10}.
    4. 28 vdc Input Changed ±4 vdc: ±1 part in 10^{10}.
- **Frequency Adjustment:** 500 parts in 10^9 total.
  Fine frequency adjustment:
  150 parts in 10^9 for 15 revolutions.
  1 part in 10^8 per revolution.
  1 part in 10^{10} per division (100 divisions per revolution).
  Coarse frequency: 350 parts in 10^9.
- **Input Voltage Requirement:** 115 vac ± 10%, 50-400 cps.
- **Emergency Battery Operating Time (full operation):** 24 hours.
    1. **Temporary Standby (Osc. only):** 48 hours
    2. **Extended Standby (Coarse Oven only):** 3 days.
- **Overall Dimensions:** 19″ wide x 17$\frac{3}{16}$″ deep x 3$\frac{15}{32}$″ high.
- **Weight:** 45 lbs. (with batteries).

Data Subject To Revision Without Notice

The Manson Model RD-180 Frequency Standard provides highly stable output frequencies of 5 Mc, 1 Mc and 100 kc for use in frequency control systems. The design objective was to construct a precision-engineered device with uncompromised reliability and performance.

Included is an emergency battery source to provide continuous operation with automatic switchover in the event of line failure.

MANSON LABORATORIES, INC.

375 FAIRFIELD AVENUE, STAMFORD, CONNECTICUT • DAvis 5-1391

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Going Up!
...higher
PRECISION
...higher
RELIABILITY

FRI CARBON FILM RESISTORS

- FOR MICROWAVE ATTENUATORS
- PRECISION COAXIAL TERMINATIONS
- DUMMY LOADS • COUPLING LOOPS
- SPECIAL APPLICATIONS

Frequency:
D.C. to 10,000 Mc
Resistance:
Disc resistors—
.001 to 400 ohms
Rod resistors—
.001 to 1500 ohms
Temperature:
−55°C to +150°C
Humidity:
0 to 100% relative humidity

FRI Carbon Film Resistors offer excellent high frequency characteristics and stability plus superior performance under pulse applications. Pyrolytically deposited films on selected substrates are completely protected with special resins. Extremely thin films and lack of spiralling, result in minimum inductances. FRI provides tight tolerances (± 1% standard), high reliability and economy in standard or special disc and rod types.

FRI

FILM RESISTORS • INC
242 Ridgedale Ave., Morristown, New Jersey
Telephone: JEfferson 8-2440

Circle Reader Service Card 44

Micromega parametric amplifiers give you this performance consistently

You can expect this kind of performance day-in, day-out with Micromega amplifiers. Low noise figure, wide tuning range, freedom from spurious responses and excellent stability are their outstanding characteristics. The parametric amplifier assembly consists of a three-port ferrite circulator, a reflection-type diode amplifier, a pump klystron, a variable attenuator, and a directional coupler monitor. For some applications, ferrite isolators may be necessary between the antenna and the circulator and/or between the circulator and mixer. Micromega engineers will custom-design these amplifiers to optimize the electrical characteristics most important for your applications. Literature and detailed information are available from the company.

Model S1000 S-band parametric amplifier

Micromega Corporation
4134 Del Rey Ave., Venice, Calif. / EXmont 1-7137

Circle Reader Service Card 45

Industry News

(Continued from page 76)

president and general manager in Apr and was elected to the board of direct in July.

Henry Feldmann came to the Unit States from his native Germany in 19 He had been plant superintendent in o of Germany's leading industrial firm and became a supervisor at Westinghou Electric and Manufacturing Co.

In 1944, with his brother and a frien he started a small plant specializing precise machining. This business d veloped into a company with annual sal close to $10 million and a national rep tation for quality and engineering exce lence in the manufacture of microwa instruments and equipment. The machi shop has grown into a 125,000 square-fo plant spread over three buildings, wi an additional 100,000 square-foot buildin being completed. From six employee FXR has increased to over 800 today, b many of Mr. Feldmann's employees the early years are still with him as supe visors and executives.

—*mwj*—

VARIAN TRANSMITTER SYSTEM FOR COMMUNICATIONS SATELLIT DESIGNED

A unique 10 kw power amplifier sy tem has been designed and built b Varian Associates, Palo Alto, Calif., t California Institute of Technology J Propulsion Laboratory specifications fo the NASA "Project Echo" West Coas transmitter.

NASA has launched the Project Ech satellite in a Delta rocket, and experi ments involving a communications sys tem between the east and west coasts o the United States by reflecting signal off the satellite are now being conducted.

At the West Coast station JPL, a re search and development facility o NASA, has erected two 85-foot diamete parabolic antennas to receive and trans mit radio and voice signals. The trans mitter was used earlier in experiments t reflect transmitted voice signals off th moon.

—*mwj*—

ROHN INAUGURATES SYSTEMS TOWER ERECTION SERVICE

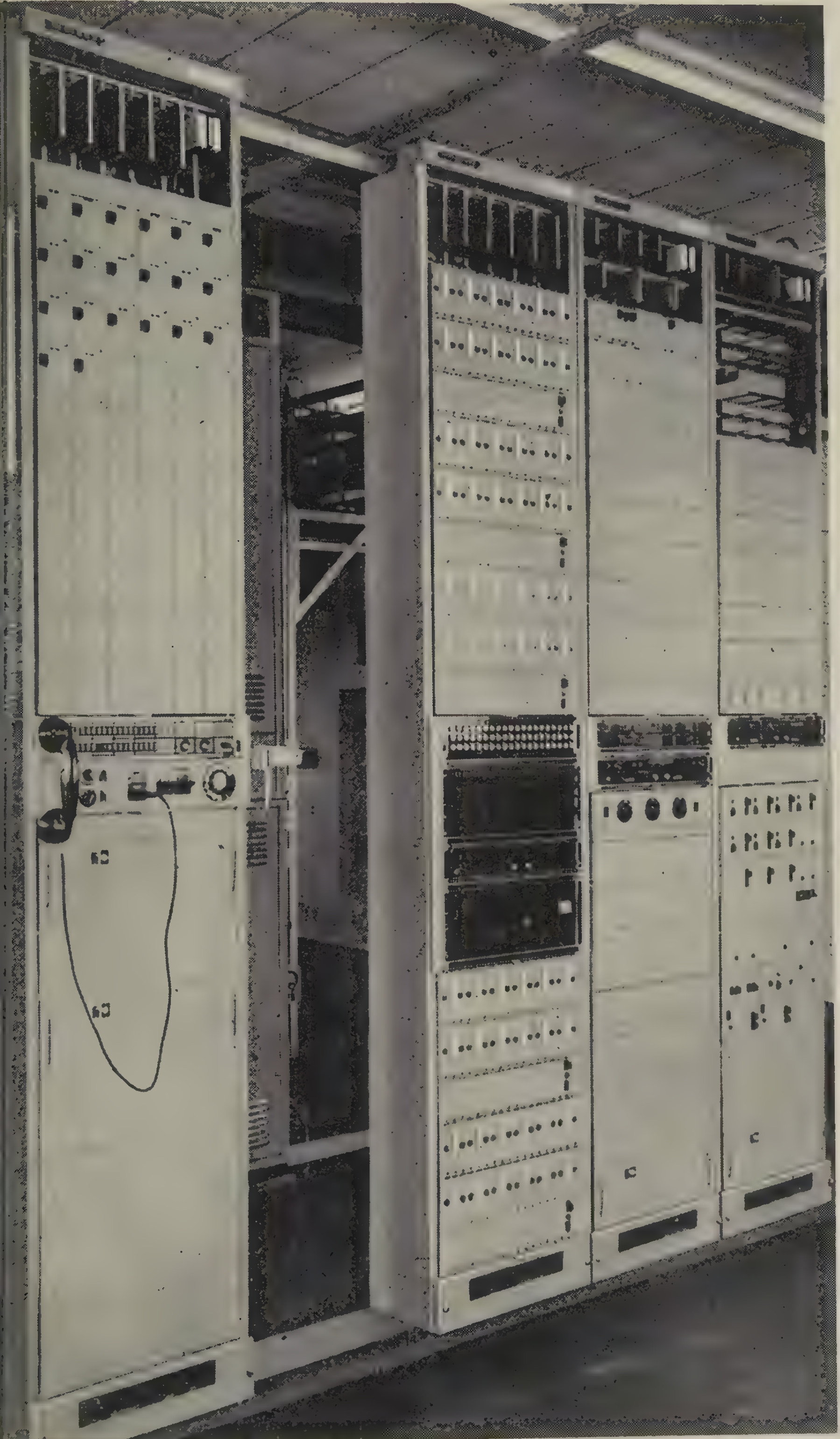
Rohn Systems, Inc., Peoria, Ill., an nounces a new tower erection service fo companies and organizations that nee the erection of complete towers an tower systems for communication and industrial purposes.

Rohn has assembled a nationwide network of local, independent tower erecto specialists. These technicians can offer many years of experience, skill and the assurance of dependable performance in the erection of complete towers and tower systems anywhere, regardless of type, number or purpose.

Further details on this new tower erection service are available from Rohn.

(*Continued on page 80*)

EC microwave carrier terminal equipment with transistor reliability



bay array of NEC 120-channel terminal equipment for microwave links

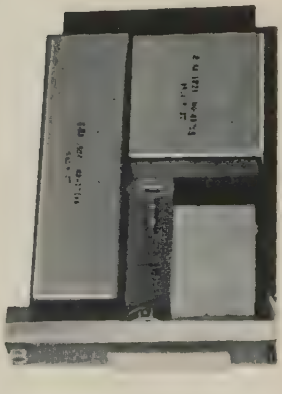
This fully transistorized carrier telephone equipment for microwave links provides 120 toll quality telephone channels. Characteristics meet or surpass all CCITT requirements.

It offers these advantages over conventional tubed equipment:

* 90% reduction in power consumption
* Lower operating temperature
* Less floor space
* Increased reliability, resulting in lower maintenance costs.

Each 300 – 3,400 c/s telephone channel can accommodate 24 voice-frequency telegraph channels operated at a keying speed of 50 bauds.

NEC will also make available within this year 600-channel transistorized equipment.



A part of print-wired channel translating unit

Communications Systems / Electronics

Nippon Electric Co., Ltd. Tokyo, Japan

EC Booth Number Franklin Hall No. 429

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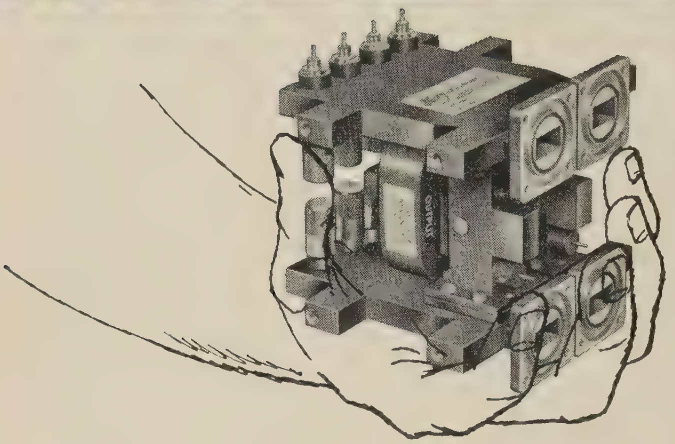
PACKAGED PRECISION
for your exact requirements



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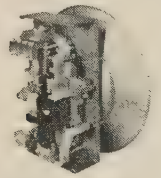
MICROWAVE SUB-SYSTEMS

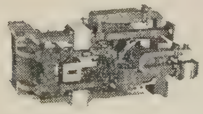
Kearfott has the experience and ability to design precision sub-systems to the customer's actual configuration and performance needs. The availability of a wide variety of standard components, coupled with advanced techniques, makes it possible to provide packaged r-f assemblies with a high component density—tailored to precise volumetric specifications. For minimum size and weight in airborne or missile applications—for military system environment—Kearfott will successfully design *your* sub-system—to *your* most exacting requirement.



Mono-Pulse Radar

S-Band Strip-transmission Head

Mixer Duplexer



High Power Mixer Duplexer

Inquiries may be directed to: 14844 Oxnard Street, Van Nuys, California

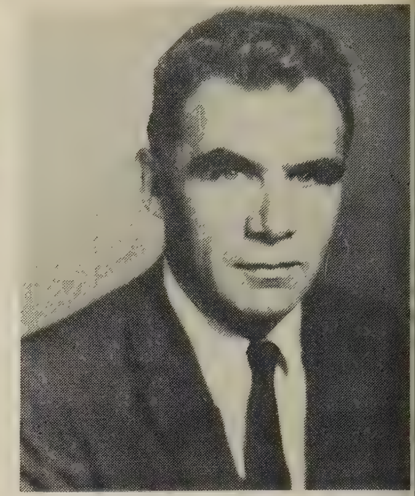
KEARFOTT DIVISION
GENERAL PRECISION, INC.

Little Falls, New Jersey

Circle Reader Service Card 47

(*Continued from page 78*)

MARION E. HINES JOINS MICROWAVE ASSOCIATES AS SENIOR SCIENTIST



Microwave Associates, Burlingt Mass. Inc., has announced the appoi ment of Mr. Marion E. Hines to newly created position of senior sci tist. Mr. Hines will coordinate the co pany's extensive research activities solid state circuits and will initiate t new programs which will lead to company's entry into microwave os lators and microwave amplifier-do converters both using Esaki (tunn diode techniques.

Mr. Hines was previously associa with the Bell Telephone Laboratori Inc. at their New York City, Allentov Penn., and Murray Hill, N.J. labo tories. He has been active in the velopment of microwave electron tub development of telephone transmissi systems and in research on solid-st electron devices. His most recent wo has been involved with research Esaki diodes for application as mic wave oscillators and amplifiers.

At the Bell Laboratories, Mr. Hi has been an instructor in electron tu for the Communications Developm Training program and has recently be a visiting lecturer at the University Pennsylvania.

Mr. Hines is a graduate of the Ca fornia Institute of Technology where obtained a BS degree in 1940 and an degree in electrical engineering in 19 He served as a weather officer in t Air Force during World War II.

Mr. Hines holds numerous patents the fields of electron tubes, electro circuits, and semiconductor devices.

—*mwj*—

LFE AWARDED TWO MULTI-MILLION DOLLAR CONTRACTS

Laboratory for Electronics, Inc., B ton, Mass., a supplier of airborne Do pler navigation equipment, has receiv from the U.S. Air Force two new co tracts expected to total $12 million.

The first contract is for continu production of the company's self-co tained, automatic Doppler airborne na ion system, the AN/APN-131. This ipment is being installed in the Tac- l Air Command's newest supersonic fighter-bomber — The F-105D "Thun- chief."

roduction is scheduled for the period y to September, 1961, and shipments l coincide with delivery of initial air- ft already under contract to Republic iation Corp. The award is part of the r-all F-105D procurement program ich is scheduled to continue through 4.

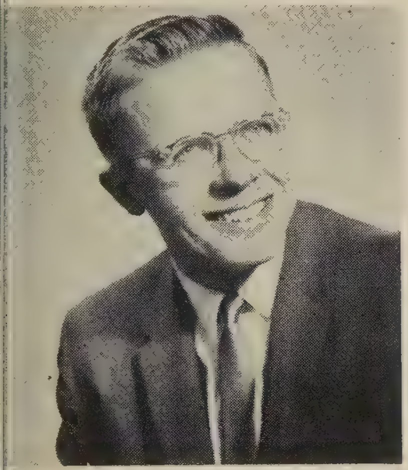
The second contract calls for spare ts and ground support test equipment APN-131's which have been delivered der prior contracts.

The two awards will bring LFE's total klog of unfilled orders to approxi- tely $40 million. Company backlog the end of the last fiscal year, ended ril 29, 1960, amounted to $28.4 mil- n.

The F-105D, produced by the Republic iation Corp., is an all-weather fighter- mber, the latest Weapons System in the enal of the Tactical Air Command.

—*mwj*—

GLENN H. SACRA APPOINTED MANAGER AT SYLVANIA'S WALTHAM LABS



The appointment of Glenn H. Sacra as anager of technical liaison for the altham Laboratories of Sylvania Elec- onic Systems, a division of Sylvania lectric Products Inc., has been an- ounced by Melvin E. Lowe, marketing anager of the Waltham Laboratories. lvania is a subsidiary of General Tele- one & Electronics Corp.

Mr. Sacra joined Sylvania as a sales gineer in 1957 and shortly thereafter as named district manager of customer lations in Rome, N.Y., a position he eld prior to the current Waltham ap- ointment.

A graduate of Cornell University, Mr. cra received a bachelor's degree in echanical engineering in 1952 and a aster's degree in business administra- on in 1954. He is a member of the In- itute of Radio Engineers, the Armed orces Communications and Electronics ssociation and the Association of the nited States Army.

—*mwj*—

(*Continued on page 32*)

Circle Reader Service Card 48 ➧

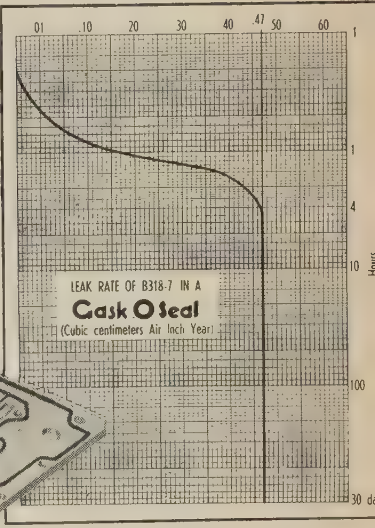
YOU CAN SEAL
VACUUM
and still get serviceability!

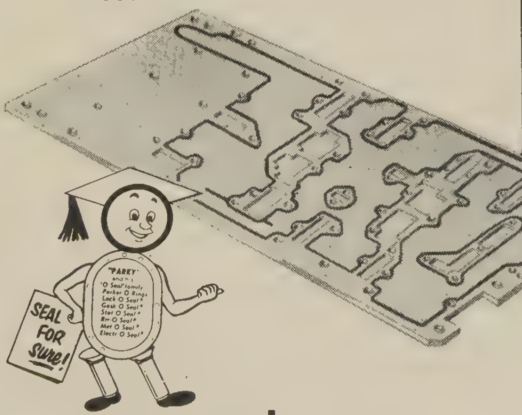
Gask-O-Seals meet, or exceed grade A MIL-8484 specifications for hermetic sealing, yet they are mechanical. That means you can seal a vacuum and still achieve full serviceability — easy access for repair, maintenance, re-setting, etc. You can seal components, "black-boxes," instruments, even complete systems — and re-seal them with the *same* seal!

The seal shown below illustrates the versatility of Gask-O-Seal — one piece seal actually doing the job of ten! Think of the freedom of design such a seal offers. Can they be put to use for your products, too?

The chart at right is an actual reproduction of a test which reveals a leak rate of less than 1 cc/air/inch/year—exceeding top hermetic requirements.

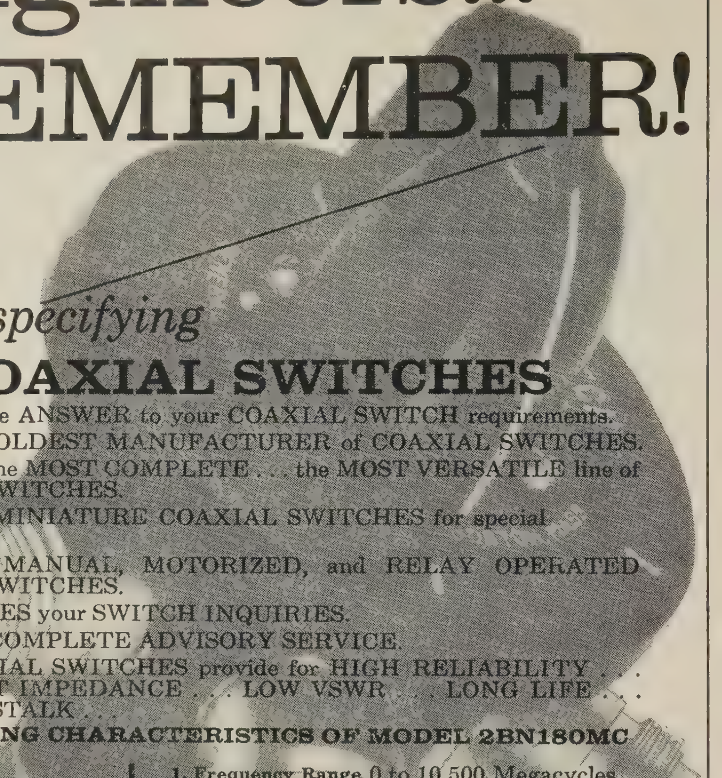
For more information about Gask-O-Seals send for catalog 5800.





Parker SEAL COMPANY
Culver City, California and Cleveland, Ohio
A DIVISION OF PARKER-HANNIFIN CORPORATION

Parker also makes Seals for Wave Guide Flanges that prevent R/F leakage and pro positive no-leakage seal; a self sealing flush-head rivet called Riv-O-Seal, and other specialized seals as well as O-Rings and Back-up Rings. Your inquiry is in



engineers... REMEMBER!

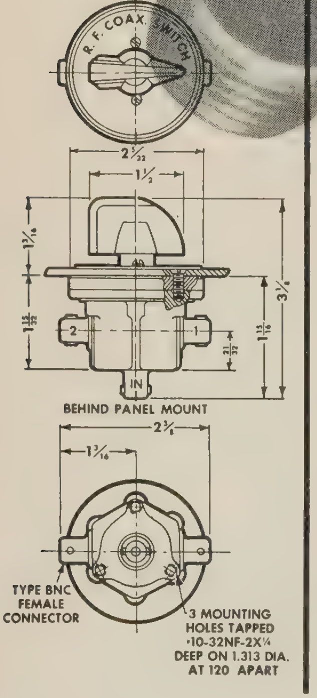
when specifying

COAXIAL SWITCHES

GCC Has the ANSWER to your COAXIAL SWITCH requirements.
GCC is the OLDEST MANUFACTURER of COAXIAL SWITCHES.
GCC offers the MOST COMPLETE . . . the MOST VERSATILE line of COAXIAL SWITCHES.
GCC offers MINIATURE COAXIAL SWITCHES for special applications.
GCC offers MANUAL, MOTORIZED, and RELAY OPERATED COAXIAL SWITCHES.
GCC INVITES your SWITCH INQUIRIES.
GCC offers COMPLETE ADVISORY SERVICE.
GCC COAXIAL SWITCHES provide for HIGH RELIABILITY . . . LOW INPUT IMPEDANCE . . . LOW VSWR . . . LONG LIFE . . . LOW CROSSTALK . . .

OPERATING CHARACTERISTICS OF MODEL 2BN180MC

1. **Frequency Range** 0 to 10,500 Megacycles
2. **R. F. Characteristic Impedance** 51.0 Ohms
3. **Voltage Standing Wave Ratio** . . . . .1.2:1 at 3,000 Megacycles
4. **Insertion Loss** 0.3 DB at 3,000 Megacycles
5. **Crosstalk (Interchannel Attenuation)** . . . . .60 DB below operating level at 3,000 Megacycles
6. **R.F. Voltage Rating** 500 volts peak
7. **R.F. Power Rating** . . . . .100 Watts Avg. at 3,000 Megacycles
8. **Operative Life** 10,000 Cycles minimum
9. **Insulation Resistance** . . . . .Greater than 500 megohms at 500 V.D.C.
10. **R.F. Connector** . . . . .Type BNC (50 ohm) equivalent of UG-291/U
11. **Connecting R.F. Cables** . . . . .50 ohm coaxial cables with type BNC connector
12. **Rotor** Non-shorting
13. **Circuit** Single pole –2 position at 180°
14. **Operating Temperature Range** . . . .−55° to +55° centigrade
15. **Weight** 14 ounces


R. F. COAX. SWITCH
2 3/32
1 1/2
1 7/16
3 1/4
1 15/32
1 15/16
21/32
2
1
IN
BEHIND PANEL MOUNT
2 3/8
1 3/16
TYPE BNC FEMALE CONNECTOR
3 MOUNTING HOLES TAPPED ·10-32NF-2X1/4 DEEP ON 1.313 DIA. AT 120 APART

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We are also engaged in Research and Manufacturing in the following fields:
RADAR TEST SETS, RADAR BEACONS, SIGNAL GENERATORS, AND PRIMARY STANDARDS FOR FREQUENCY, VOLTAGE AND PULSE POWER CALIBRATION

Circle Reader Service Card 49

Industry News

(*Continued from page 81*)

LITTON SIGNS AGREEMENT WITH JAPANESE FIRM

An agreement signed between Litt Industries, Beverly Hills, Cal., and Kol Kogyo Corp., Japan, has been submitt for approval to the Minister of Intern tional Trade and Industry of the Japane government and to the State Departme of the United States.

The agreement establishes a workii relationship in the microwave and oth electron tube fields between the two c ganizations on a long-term basis, accor ing to Charles B. Thornton, president Litton Industries. This will be Littor first manufacturing relationship in Japa Thornton said.

Kobe Kogyo Corp. has been outstandi in the development and manufacture electron tubes and other electronic d vices, semi-conductors, nuclear equi ments and precision machinery. Net sal have nearly tripled since 1956 and, in tl fiscal year ending 1959, totalled mo than $17,000,000. Personnel excee 4,600 with office and factory areas tot ing almost 1,300,000 square feet.

President and director of Kobe Chohei Aida.

Litton Industries' Westrex Corp. D vision for many years has maintained office in Toyo. This office, with branch throughout Japan, also represents tl other divisions of Litton Industries.

—*mwj*—

1960 ELECTRON DEVICES MEETING COMING

Parametric and tunnel diode devices- new areas in solid-state research — wi receive major emphasis at the 1960 Ele tron Devices Meeting, to be held Washington, D. C. on October 27 and 2 This meeting is sponsored by the Pr fessional Group on Electron Devices the IRE.

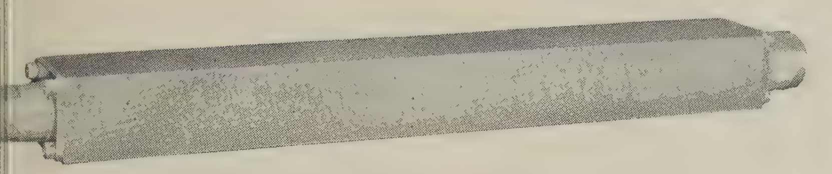
Other subjects to be explored in deta at the Meeting are multimegawa traveling-wave tube and klystron ampl fiers, the cyclotron wave traveling-wa tube as a low-noise amplifier, and th epitaxial film technique which has bee developed for making new and bett solid-state devices. Papers will be pr sented on the parametric amplifier, a d vice which has now reached the stag where it can be incorporated into equi ment as a wide-band, stable, low-noi amplifier.

Two full days of technical sessions wi be held and special luncheon progran are being planned. The primary purpo of the meeting is to provide a forum t discuss recent advances in development techniques and devices in the fields vacuum tubes and semiconductors.

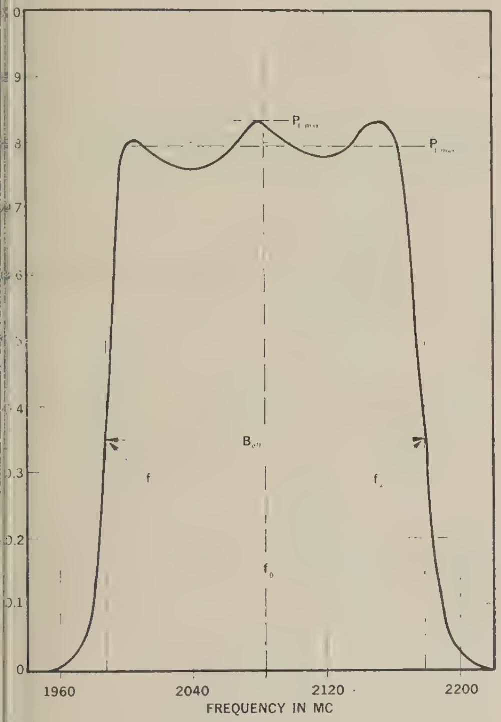
The technical program is being orga ized by Dr. H. W. Welch, director of R search and Development at Motorol Inc. Assisting him are Harry Knowles Motorola Inc. on semiconductors; Joe Hull of Litton Industries on microwav

(*Continued on page 84*)

MC μ/φ Microwave Components



CALIBRATED BANDPASS FILTER



Bandpass Filters, the attenuation characteristics of which follow a prescribed mathematical equation, may be effectively used to make noise measurements in the microwave regions. The unit illustrated here is an S-Band "window" which has a specific Effective Bandwidth.

Microwave-noise measuring filters are defined in terms of a center frequency and an effective bandwidth. This bandwidth is obtained by integrating the relative power-transmission coefficient, which is a function of frequency, about the transmission range and dividing it by the max. transmission coefficient.

$$B_{eff} = \frac{1}{P_t, \text{max.}} \int_0^{3f_o} P_t(f)df ,$$

where $P_t = \frac{\text{Transmitted Power}}{\text{Incident Power}}$

and P_t, max. = Maximum P_t or Mean ripple.

An additional requirement which describes the degree of selectivity is:

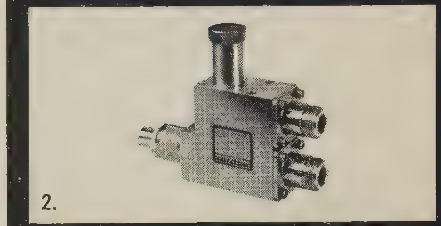
$$\int_0^{f_1} P_t(f)df + \int_{f_2}^{3f_0} P_t(f)df < 0.1 \int_{f_1}^{f_2} P_t(f)df ,$$

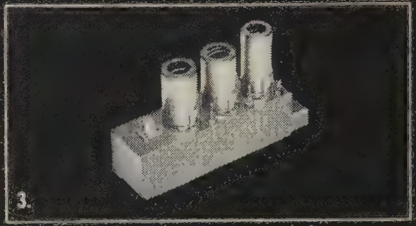
where $f_1 = f_0 - \frac{B_{eff}}{2}$

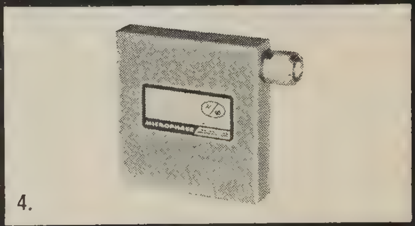
and $f_1 - f_0 + \frac{B_{eff}}{2}$.

These filters are available from Microphase in the S through X-Bands with a variety of effective bandwidths. These units offer a minimum of 50 db rejection from DC through the third harmonic of the center frequency, except for the pass range.

1.


2.


3.


4.

1. Wide-Band Video Detector has integral DC return and operates from 1 kmc to 10 kmc. Tangential sensitivity averages better than −45 dbm over this frequency band.
2. Broadband Single-Ended Mixer. Improved L.O. coupling circuit permits operation over wide bandwidths. This mixer requires 10 mw L.O. power, operates between 2 kmc and 6 kmc with a noise figure of 8.5 db (1.75 db I.F.)
3. Compact Low-Noise Preamplifier operates at 30 mc with 1.5 db noise figure and 40 db gain. This amplifier is designed to operate between a single-ended mixer and a 50-ohms amplifier in sensitive microwave systems.
4. Part Number SSLO-(desired frequency) Complete Solid-State Frequency Source, crystal-controlled. Available in any frequency range from 100 to 1200 mc. Stability better than .002% over wide temperature range.

MICROPHASE CORPORATION

ox 1166W Greenwich, Conn. NO 1-6200 WE 9-9190 TWX GNWICH CONN 759

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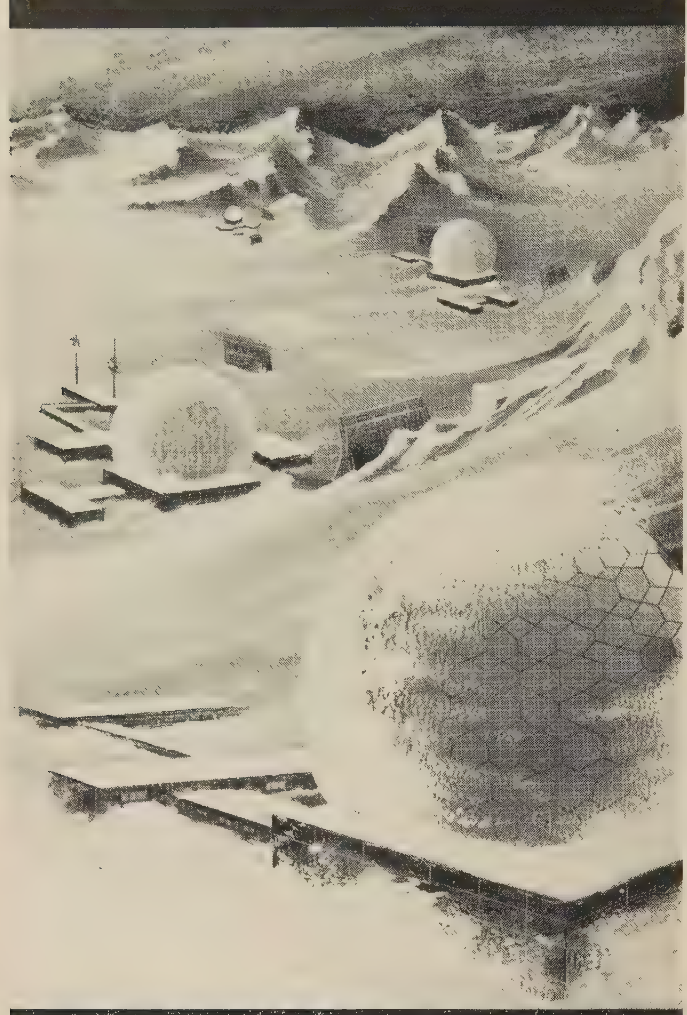
WE CAN'T AFFORD A HOLE IN THE NET!



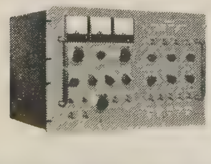
MILLIONS of dollars have been spent in establishing radar early warning protection around our nation. One hole in this system . . . one inaccurately functioning radar . . . and the "fish" might slip through.

Determining that this vital radar is accurate and reliable is the job of Remanco.

RADAR TARGET SIMULATION

Remanco is an entire order of magnitude ahead of the field in developing and producing radar target and countermeasures simulation equipment, including single target, multiple target to "n" quantity, video, IF and Microwave target simulators.

Remanco equipment can provide pin-point accuracy in moving target simulation to 0.1% in ranges to 20,000 microseconds. It can be programmed for target velocities up to 75,000 feet per second and acceleration of 50 g's.



Write for folder giving complete details. Address inquiries to: Remanco, Inc., 1805 Colorado, Santa Monica, California.

REMANCO

Circle Reader Service Card 51

Industry News

(*Continued from page 82*)

tubes, and H. Millard Smith of Hugh Aircraft on display tubes and misc laneous.

Chairman of the General Committ for the meeting is Dr. John A. Hornbe of Bell Telephone Laboratories. Local rangements are being handled by Dr. P. Marsden, Jr. of the National Bureau Standards, publications by Dr. Earl Steele of Hughes Aircraft, and public by H. S. Renne of Bell Telephone Labo atories.

The PGED is an association of me bers of the IRE with professional inter in the research, development, design a application of electron tubes and so state devices, and in scientific, technic industrial and other activities that co tribute to the field. The group encourag close cooperation and exchange of tec nical information among its members.

—*mwj*—

LFE AFFILIATES WITH ITALIAN ELECTRONICS FIRM

Laboratory For Electronics, Inc., Bo ton, Mass. has acquired an interest Segnalemento Marittimo ed Aereo, S.p. (SMA), Florence, Italy, according Henry W. Harding, LFE president.

SMA, formed through an arrangeme of the Italian ministry of Defense, Nav and Barbier Benard & Turenne, Par France, ". . . was established in 1943 fill the great need in Italy for mari signalling equipment for the Beac Service," he said.

"Since that time, SMA's advanced ele tronics capability has led to developme and production of marine navigatio radars, and microwave, infrared, lighti and signalling equipment, all produc complementing our own capabilities airborne Doppler navigation systems ar Tactical Ground Control Approach R dars," Mr. Harding noted.

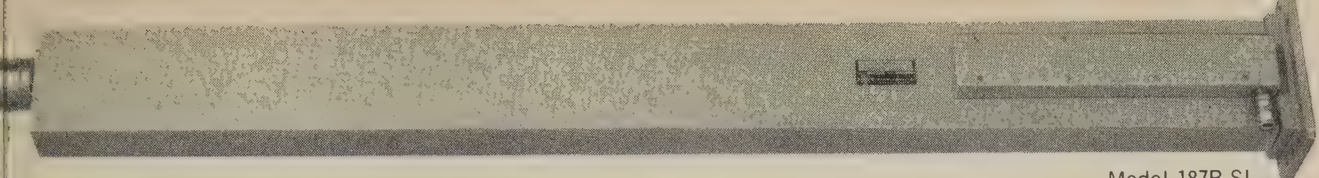
The purchase, he said, is in line wi LFE's continuing program to develop worldwide marketing and manufacturin facility.

Mr. Harding joins Professor Lorenz Fernandes, SMA founder and managin director; Enrico Calvo, SMA preside and chairman of the board; Christia Benard, managing director of Barbi Benard & Turenne; Eng. Menotti Ri cioti; Sir Federico Albini; and Professo Nello Carrara on the SMA board o directors.

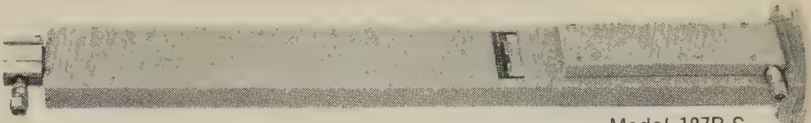
Professor Carrara, a director of t Microwave Research Center of the Italia government's National Research Counci is also an SMA technical consultan Noted for his work in electromagnet waves, he is official Italian member o the International Radioscientific Unio Professor Fernandes, and others of SMA technical staff, have visited LFE as pa of the technical exchange program no in progress.

Liaison with SMA, as with other of th company's overseas affiliates, will b directed by LFE's International Divisio

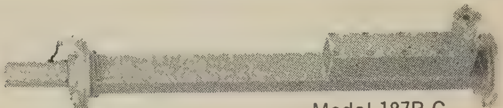
(*Continued on page 112*)


Model 187B-SL

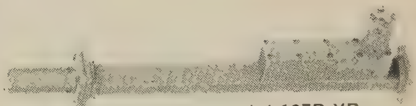
OMPLETE LINE


Model 187B-S

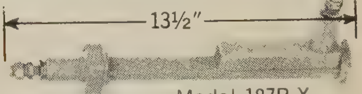
F VERSATILE, EFFICIENT


Model 187B-C

AVEGUIDE WATER LOADS


Model 187B-XB

or SL, S, C, XB and X Frequency Bands



Model 187B-X

Five models covering five bands
Three models useful in pressurized systems
VSWR less than 1.10
Can handle 2-20 kw average power
Low rf radiation
Calibration heaters in all models

These Sierra high-power waveguide terminations are extremely useful as dummy loads in calorimetric power-measuring systems. They feature rugged construction, with rigid plastic water tube mounted in waveguide section, diagonally oriented for impedance matching. Chokes and shielding minimize rf leakage, and a heater element built into each model permits rapid, accurate calibration of a calorimetric power-measurement system against a low-frequency standard.

CHECK ALL THESE SPECIFIED ADVANTAGES!

Model Number:	**187B-SL**	**187B-S**	**187B-C**	**187B-XB**	**187B-X**
Frequency Range:	1.7 to 2.6 kmc	2.6 to 4.0 kmc	5.8 to 8.2 kmc	7.0 to 10.0 kmc	8.2 to 12.4 kmc
VSWR:	< 1.10 to 2.4 kmc < 1.15 to 2.6 kmc	less than 1.10	less than 1.10	less than 1.10	less than 1.10
Power Average: (Unpressurized)	20 kw	10 kw	5 kw	3 kw	2 kw
Peak Power:	2 megawatts	1 megawatt	500 kw	250 kw	150 kw
Max. Air Pressure:	*	*	45 psig	45 psig	45 psig
Waveguide:	RG-105/U	RG-75/U	RG-50/U	RG-51/U	RG-52/U
Connector:	UG-437A/U	UG-584/U	UG-344/U	UG-51/U	UG-39/U
Recommended Water Flow:	2 gpm for 10 kw	2 gpm for 10 kw	1 gpm for 5 kw	0.6 gpm for 3 kw	0.4 gpm for 2 kw
Pressure Drop at Rated Flow:	10 psi	10 psi	10 psi	10 psi	10 psi
Max. Water Pressure:	80 psig	80 psig	80 psig	80 psig	80 psig
Water Temperature:	0 to 70° C	0 to 70° C	0 to 70° C	0 to 70° C	0 to 70° C
Water Capacity:	18.5 cu. in.	3.5 cu. in.	0.85 cu. in.	0.42 cu. in.	0.20 cu. in.
Water Renewal at Rated Flow:	Once per 2.5 sec.	2 times per sec.	4.3 times per sec.	5.3 times per sec.	7.4 times per sec.
Heater Resistance:	4.5 ohms	9 ohms	14 ohms	20 ohms	20 ohms
Heater Rating:	10 kw at 2 gpm	5 kw at 1 gpm	3 kw at 1 gpm	1 kw at 0.6 gpm	1 kw at 0.4 gpm
Length:	50 in.	32 in.	20 in.	17.25 in.	13.5 in.
Price:	$600.00	$500.00	$425.00	$400.00	$375.00

*Not pressurized

Data and prices subject to change without notice. Prices f.o.b. factory

For complete details, see your Sierra Representative or write direct.

NEW! Sierra also offers its Model 186 Series Coaxial Water Loads, covering dc to 4 kmc.

sierra

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6807

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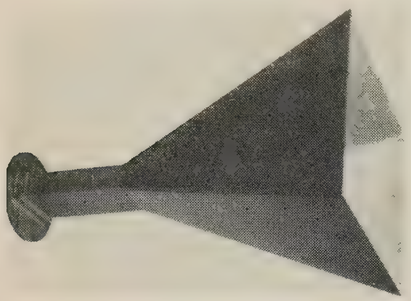
New Products

NEW STANDARD GAIN HORNS ANNOUNCED



Featuring wide frequency coverage and high gain, a new series of standard gain horns has been announced by Scientific-Atlanta, Inc., Atlanta, Georgia, to provide accurate and practical microwave antenna gain standards.

The Atlanta firm's SGH Series consists of 14 broad-band waveguide horns which cover the microwave bands from 0.95 to 90 kmc. The horns are of lightweight, rugged construction.

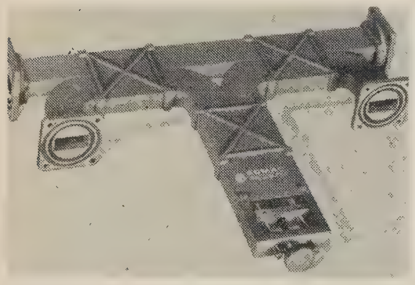
Each horn is furnished with accurate gain vs. frequency characteristics. Horn dimensions and calibration data are taken from NRL Report No. 4433.

All aluminum horns are anodized to prevent corrosion; brass horns are silver-plated and protected with a rhodium flash. Series SGH horns may be mounted on any of the Scientific-Atlanta Series PP 10 Transmitting Antenna Polarization Positioners.

Circle Reader Service Card 100

— m w j —

NEW BOMAC COMPONENT INTRODUCED



A variable power divider recently introduced by Bomac Laboratories, Inc., Beverly, Mass. provides a highly useful tool for the designer of microwave components requiring a variable power source for test purposes.

One unit, for example, when provided with two suitable loads, will transmit microwave energy to the output terminal at a level which may be varied from zero to essentially full input power. The unit is bi-lateral; power may be passed into it at any terminal. Either of the two terminals opposite the input terminal can be used as the output terminal. A load capable of receiving full transmitted power is then attached to the remaining arm. Adjusting the knob will gradually shift output from one output terminal to the other, providing a variable power level at the selected terminal.

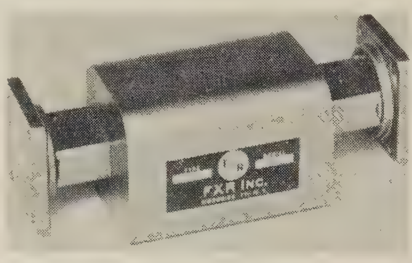
Four models are available, ranging in frequency from 2.6 to 17.0 kmc.

Bomac variable power dividers can also function as diplexers, devices used to mix two signals of different frequencies while maintaining considerable isolation between them. Isolation of 25 db or more between transmitter and receiver is possible, through a common antenna and without switching.

Circle Reader Service Card 101

— m w j —

FXR ADDS FERRITE ISOLATORS TO ITS MICROWAVE LINE



FXR, Inc., Woodside, N.Y., manufacturer of microwave and other electronic equipment, has added a complete line of broadband waveguide and coaxial ferrite isolators, FXR Series 157, to its line of precision microwave test equipment.

These new high performance components provide maximum isolation and minimum insertion loss when used to reduce the VSWR presented by a load or antenna or when eliminating irregularities caused by long line effects in oscillator outputs. The instruments are intended, primarily, for bench test setups.

Six broadband waveguide models have frequency ranges from 3.95 to 26.5 kmc. The single coaxial model has a frequency range of 2 to 4 kmc. All models are rated at 10 watts average power and up to 2 kw peak power.

Deliveries are from 30 to 45 days.

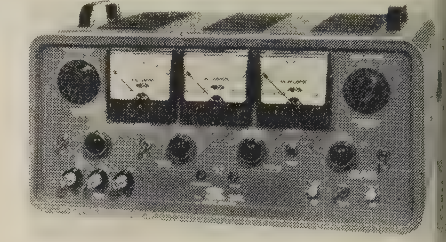
Circle Reader Service Card 102

— m w j —

NARDA ANNOUNCES MODEL 10003 MICROWAVE MODULATOR

The model 10003 Microwave Modulator, designed for operation with beacon type magnetrons such as are used in navigational radar, and available for other applications with similar requirements, has been announced by the Narda Microwave Corporation, Mineola, L.I., N.Y.

An extremely small package (8 1/2 inches high x 18 inches wide x 12 inches deep), the Narda model 10003 contains an internal generator that provides a pulse width from 200 to 4,000 pps; puls voltage from 0 to 5 kv; and pulse current of 2 amps maximum. Pulse repetition rate is continuously variable ove the range from 0.4 to 2.2 microseconds.



Silicon rectifiers, used exclusively in both high voltage and low voltage supplies, serve to conserve space and provide freedom from excessive heat, thu ensuring longer life from components. Safety features include automatic sequencing circuit, overload sensing circuits and discharge circuits.

Front panel meters indicate directly the high voltage power supply voltage and average current supplied to the tube being powered. The filament supply voltage is controlled by a direct reading front panel control and filament supply current is shown on a front panel meter.

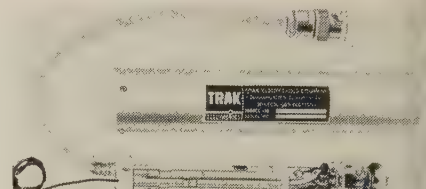
A sync. pulse is available through a BNC connector for synchronizing external equipment to the repetition rate of the internal rate generator. It is also possible to synchronize the internal repetition rate of the internal rate generator with an externally fed pulse.

Weight of the Narda model 10003 is 45 pounds. Priced at $2450, the unit is available from stock.

Circle Reader Service Card 103

— m w j —

TRAK ELECTRONICS ANNOUNCES NEW L-BAND OSCILLATOR



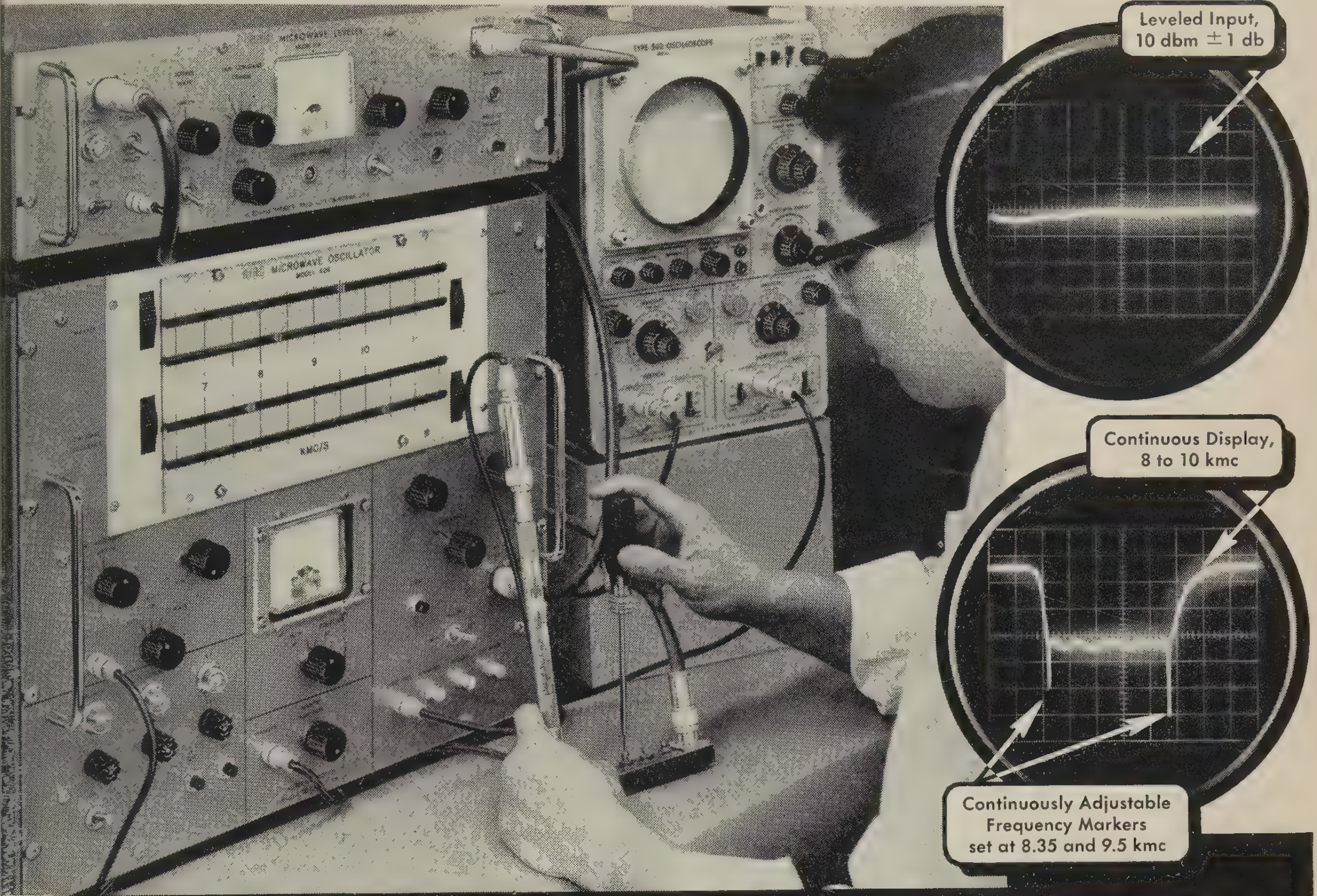
A new miniature Type 9127-L Oscillator end-tuned over the range of ±25 mc at 1090 mc has been developed by Trak Electronics Co., Wilton, Conn. The oscillator can be used in expendable systems. It is available in frequencies of 900-1200 mc and is available for immediate shipment in small lots. Further information is available from the manufacturer.

Circle Reader Service Card 104

— m w j —

(*Continued on page 88*)

ting insertion characteristics of X-band filter with Alfred Swept Generator. It consists of Alfred crowave Oscillator and Alfred Microwave Leveler. This combination electronically sweeps freency linearly with respect to time while maintaining RF power virtually constant across the band.



Save Test Time, Assure Test Accuracy

with ALFRED'S new SWEPT Microwave Generator...........

The scope patterns tell the story. Top pattern shows constant power input from Alfred Swept Generator to component (filter) under test. With known input, variation in output is due to filter characteristics. Lower pattern is especially significant, showing continuous, flicker-free display, 8 to 10 kmc. Any changes in stubs or irises are immediately reflected. Measurement accuracy is assured *at every frequency*, not just at selected points.

HIS TECHNIQUE CAN BE USED FOR MOST PRESENTLY KNOWN MICROWAVE TESTING PPLICATIONS. HERE'S WHY IT'S FASTER THAN CONVENTIONAL SIGNAL GENERATORS:

* *Continuous Display* allows immediate neasurements – no plotting needed. Trace can be recorded if desired.

* *Sweep Technique* eliminates time-conuming "point-to-point" frequency and ower setting methods of conventional ignal generators. Sweep range is continously adjustable with 1% accurate Direct Reading Slide Rule Dial.

* *"Quick Look Readout"* eliminates calulations in setting sweep range.

* *Adjustable Frequency Markers* allow apid, broadband calibration of scope or ecorder trace.

SOME MORE FACTS YOU SHOULD KNOW

✱ *Frequency Ranges.* The Swept Generator is available in five ranges to 12.4 kmc – 1 to 2, 2 to 4, 4 to 8, 7 to 11, 8.2 to 12.4.

✱ *Stability.* At any single frequency, stability of the Swept Generator equals that of a conventional signal generator. Spurious modulation is low.

✱ *Power Output.* Greater than a signal generator: 10 milliwatts as compared to 1 milliwatt.

FUNCTION OF THE LEVELER It holds power output constant to ±1 db over standard frequency ranges, and better than ±1 db over narrower ranges. The Leveler serves as a broadband attenuator with up to 20 db dynamic range control, providing constant output over a wide range. It can be used as a general purpose instrument for a wide variety of oscillators and amplifiers.

For more details on the Alfred Swept Generator – please contact your Alfred sales engineering representative, or write direct.

Key specifications for Signal Generators available for coverage from 1 to 12.4 kmc

requency – Controls: Continuously adjustable with direct calibrated dial. Calibraion accuracy: 1%. Stability: ±0.02%/hr. Residual FM: ±0.0025%. **Power Output Minimum):** 10 mw ±1 db. Continuously adjustable from zero to maximum. **Attenuation Range:** Up to 20 db. **Sweep** – Selector: Recurrent Sweep, Single Sweep, Single Frequency, and External on panel switch. Time: 100 to .01 seconds, coninuously adjustable. **Monitor Output** – Sweep Out: Positive linear sawtooth, 45 volts peak. Panel BNC connector. **Amplitude Modulation** – Internal Square Wave: RF output is alternately 0 and unmodulated CW value. Frequency 800 to 1200 cps, adjustable by panel control.

7

ALFRED ELECTRONICS

897 COMMERCIAL STREET
PALO ALTO, CALIFORNIA

Circle Reader Service Card 53

SUPER-DRY Air...

the perfect dielectric for transmission media

SAVES YOU MONEY

when produced with

TRINITY EQUIPMENT

Heat-Les DRYERS

Dynamic desiccant dryers providing dewpoints below −100°F. No bothersome, expensive heaters. Completely automatic. Available in all capacity ranges. Install with compressor, or air supply of your choice...

UNITIZED DRY-AIR SYSTEMS

Completely self-contained, ready-to-operate super-dry air systems supplying continuous, dependable purging. Completely automatic, requiring only occasional routine maintenance checks. Ideal for unattended installations. Available in all capacity ranges in militarized and standard packages.

Super-dry air is your most economical, dependable dielectric for purging transmission lines and associated equipment. Trinity equipment is currently used by both the military and commercial design and manufacturing groups to assure maximum performance and greatest dependability.

WRITE FOR COMPLETE TECHNICAL DATA...

TRINITY

World leader in dry gas/air systems

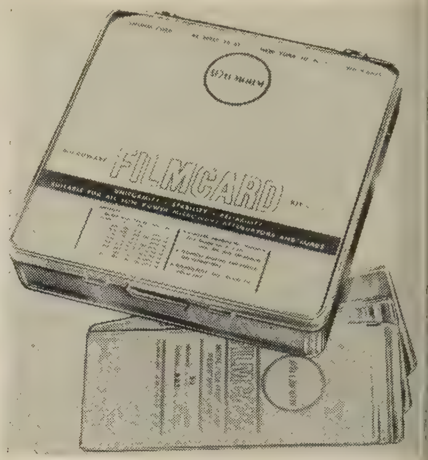
Heat-Les Dryers • Heat-reactivated Dryers
Thermocouples and Thermowells

TRINITY EQUIPMENT CORPORATION, CORTLAND, NEW YORK

Circle Reader Service Card 54

(*Continued from page 86*)

FILHOHM OFFERS METAL FILM MICROWAVE RESISTANCE CARD KIT



A complete, practical kit containing a varied assortment of high stability microwave attenuator material in easy-to-use card form was recently announced by the Filmohm Corp, New York, N.Y. The new Filmcard Kit includes 11 metal film resistance cards 2 1/2 inches x 6 inches, and one metallized mica resistance card, 2 inches x 2 1/2 inches plus fabrication instructions and technical notes. It is priced at $40.00, F.O.B. New York.

Recommended for microwave applications requiring accurate, reproducible dissipation at low RF power, these cards may be punched, drilled, machined or sanded to suit particular needs. Meeting MIL-P-18177 specifications, Filmohm Filmcards are available in a resistance range of from 25 to 750 ohms/square and in standard values of from 50 to 500 ohms. They are guaranteed electrically, uniform, and dimensionally stable, according to the manufacturer and have a standard resistance tolerance of ± 10 per cent per square. While attenuation values up to 70 db are obtainable, the VSWR can be held to less than 1.10 over broad bands.

Applications include use as microwave attenuators and terminations, directional couplers, isolation and impedance matching, crystal protection and mode suppressors.

Further details may be obtained on request.

Circle Reader Service Card 105

—*mwj*—

NEW HERMETICALLY SEALED VARACTOR DIODES INTRODUCED

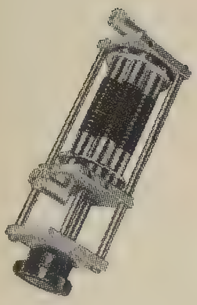
Type MA-4297 silicon mesa varactor diodes with 120 kmc cutoff frequency have been introduced by Microwave Associates, Inc., Burlington, Mass. The new diodes are housed in hermetically sealed reversible-polarity cartridges with outline dimensions similar to MA-450 series varactor diodes.

Shunt capacitance is on the order of

(*Continued on page 90*)

MINIATURIZED TURRET ATTENUATORS FROM 0 TO 10 KMC FOR IN-LINE AND PANEL MOUNTING

From MICROLAB, here is a complete line of miniaturized turret attenuators for use as laboratory instruments or components in military and field equipment.



AS Series—
Six fixed attenuators mounted about a central shaft and selectively engaged by means of a coaxial switch. For use in the 4000 to 10,000 mc region, they are the only turret attenuators available that can be used in the X band range.

AT Series—
Similar in design to the AS Series, they are designed for use in the DC to 5000 mc range and are available in 2, 5 and 15 watts.

AV Series—
The smallest, lightest variable step attenuators available, they consist of six or more coaxial attenuators mounted within a single housing. Characterized by low VSWR and zero insertion loss, they are used from DC to 2000 mc.

AW Series—
Waterproof, environmental-resistant, variable step attenuators for use from DC to 4500 mc with low VSWR and zero insertion loss. Their low cost and rugged design make their use practical where other models are prohibitively expensive and delicate.

For in-line mounting.

AX Series—
Waterproof, environmental-resistant, variable step attenuators for use from DC to 4500 mc with low VSWR and zero insertion loss. Similar to AW Series attenuators but designed for front-panel mounting.

TURRET ATTENUATORS

MICROLAB SERIES	AS	AT (2 watt)	AT (5 watt)	AT (15 watt)	AV	AW	AX
FREQUENCY RANGE (kmc)	4-10	0-5	0-5	0-5	0-2	0-4.5	0-4.5
ATTENUATION VALUES (db)	0-20	0-60	0-30	0-60	0-20(3)	0-30	0-30
MAXIMUM VSWR	1.40	1.30	1.40	1.40	1.25	1.30	1.30
ACCURACY (db) (1)	±0.5	±0.5	±0.5	±1.0	±0.7	±0.5	±0.5
POWER, AVERAGE (watts)	2	2	5	15	2	2	2
POWER, PEAK (kw)	2	2	3	3	1	2	2
OVERALL LENGTH (in.) (2)	8.4	6.9	8.1	10.5	2.8	3.3	4.7
WEIGHT (oz.) (2)	33	27	31	40	6.1	9.7	13.3
METHOD OF ADJUSTMENT	knob	knob	knob	knob	(4)	(4)	knob
PUSH-PULL MOTION REQ'D	yes	yes	yes	yes	no	no	no
PANEL MOUNTING	yes	yes	yes	yes	no	no	yes
CHASSIS MOUNTING	yes	yes	yes	yes	no	no	no
WATERPROOF	no	no	no	no	no	yes	yes
PRICE (1) (2)	280.00	250.00	340.00	430.00	150.00	220.00	240.00

NOTES: (1) 10 db nominal (2) Type N connectors (3) Per turret (4) Knurled finger grip on rotating tumbler

MICROLAB

570
W. Mt. Pleasant
Avenue
Livingston, N. J.

WYman 2-5700

Circle Reader Service Card 55

NO. 5 OF A SERIES

He Can Say "No" and Make It Stick!

For he is the Manager of Quality Control here at Weinschel Engineering. His job is to see that every piece of equipment that leaves this plant meets our high standards of quality and no amount of pressure from Sales or Production, or even from a customer, can influence him a bit. We try to ship on schedule, but we would much prefer to sacrifice promptness for quality when a choice must be made.

This is part of our general philosophy of business. Weinschel Engineering was founded in 1948 by a small group of scientists who were convinced that rapid technological advances had made imperative the development of means for obtaining microwave measurements of higher precision and reliability. In a relatively few years, this small group has expanded into a research, development and production organization that is supplying instruments to a constantly-growing list of customers in commercial and military establishments all over the world.

Of course, we are proud of this growth, but we are prouder still of living through it without losing sight of our original objectives. Weinschel Engineering is first, last and always a scientific organization managed by scientists. We've learned to be production-conscious and sales-conscious, but we are still as quality-conscious as we were when we started. We are in business to create and build precision microwave instruments and our goal is to make every instrument we produce more accurate, more reliable and longer lasting than the customer expects it to be.

So the next time you order an instrument from us, and we hope it will be soon, bear with us if we can't deliver it as promptly as you want it. Expedite us, if you will, and we'll do our very best to speed things up. But, until Quality Control gives the word, we can't ship.

® WE CO
Specialists in Precision Microwave Calibration Equipment
Weinschel Engineering
KENSINGTON, MARYLAND

New Products

(*Continued from page 88*)

0.4 $\mu\mu$fds and approximate series lead inductance is 2 x 10^{-9} henries.

Low capacitance MA-4297 varactors used in 5500 megacycle nondegenerate parametric amplifier equipped receivers are reported to have achieved stable overall receiver noise figures of 2.2 db for ± 10 megacycle bandwidth. Stable overall receiver noise figure of under 1.8 db is reported for 3000 megacycle radar receivers using nondegenerate parametric amplifiers with ± 10 megacycle bandwidth at the 3 db point.

In both cases above, single sideband values are cited and ferrite circulator insertion losses are included.

Noise figures of 0.5 db are reported in radio astronomy equipments operating in the 1420 megacycle region, using the MA-4297 varactors.

MA-4297 silicon varactor diodes are now available in experimental quantities. Price and delivery data is available from Microwave Associates.

Circle Reader Service Card 106

—*mwj*—

NEW MICROWAVE FREQUENCY CALIBRATOR ANNOUNCED

Harmonics up to 25 kmc can be generated with the new Microwave Frequency Calibrator Model #101, it was announced recently by the Micro-Now Instrument Co., Chicago, Ill.

The 450 mc crystal controlled signal is designed to feed directly into a waveguide or coaxial crystal holder. A 5 mc fundamental crystal provides a convenient means of calibrating the instrument against wwv. Lower intensity markers at 150 and 50 mc are present for wavemeter or receiver calibration.

Circle Reader Service Card 107

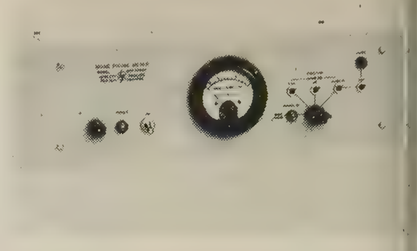
—*mwj*—

NEW NOISE FIGURE METER MONITORS RADAR SETS

A new noise figure meter which directly and continuously monitors the noise figure of operating radar sets is now available from Hewlett-Packard Co., Palo Alto, Cal.

The noise figure meter, model 344AR, is a rugged, militarized instrument which operates automatically and includes a simple front panel calibration. It operates on either a 25 or 30 mc IF Frequency, and is designed for direct application to pulse radars with repetition rates of 90 to 500 pps, or up to 3000 pps with special sampling circuitry. The instrument's fast meter response enables the operator to optimize or a just the radar system during operati or maintenance.

With the compact and transistoriz 344AR, system noise figure is measur on a time-shared basis with the rad



scan. The unit's high sensitivity mi mizes signal and transmitter losses; t noise source may be decoupled 20 from the main transmitter line. Tv alarm functions give visible and elect cal indication when an allowable noi figure is exceeded, or a noise source m functions.

In its free-run mode, the 344AR me sures receiver noise figure without tu ing on the transmitter or radar timi circuitry. It thus simplifies period measurement and maintenance pro dures.

The instrument's noise source a modulator are separate units which m be mounted on an antenna structure (th high voltage connections are short a do not require slip rings) or in an a craft. In the latter case, weight a space are saved and only low volta connections need be made to measu noise figure on the ground.

The rack-mounted 344AR, only 5 1 inches high, is priced at approximate $1,600, depending upon options a modifications. Price and delivery are d termined by the options desired.

Circle Reader Service Card 108

—*mwj*—

SYLVANIA ANNOUNCES TWO TRAVELING WAVE TUBES

Sylvania Electric Products Inc., Mou tain View, Cal., has announced tw temperature compensated, magnetical shielded, traveling wave tubes, designe for "close quarters" in airborne a missile applications.

Thomas D. Fuller, marketing ma ager of Sylvania's Special Tube Oper tions, said the new components (TW 4002F and TW-956H) employ period permanent focusing and are particular well suited to the rigorous requiremen of the military. They are designed f both pulse and CW operation.

"Use of magnetic shielding makes po sible extremely close packing with n performance concessions," Mr. Fuller e plained, "while the periodic permane net focusing eliminates the need for noids."

n addition, both types operate with- heater blankets from minus 65° to 72°C with minimum performance radation," Mr. Fuller said. They a relatively flat frequency response an octave, from 2.0 to 4.0 kmc. n unit weighs approximately three nds, is about 15 inches long, and has 4 inch capsule diameter.

oth of the new Sylvania tubes are manent magnet focused with the following specifications at room tempera- : Type TW-4002F-small signal gain 7db minimum; CW RF power output uration) is 10 mw minimum. Type -956H-gain with 0.1 milliwatt input minimum 37 db; CW RF power out- (saturation) is 2 to 5 watts.

amples for evaluation in military ipment are available. Prices for small ntities are about $1200 for the TW- H and about $1950 for the TW- 2F. Commercial versions are also ilable.

Circle Reader Service Card 109

—*mwj*—

GH GAIN, HIGH TEMP. COAX. ANTENNAS DEVELOPED BY DON-LAN ELECTRONICS

A family of sub-miniature coaxial an- nas capable of constant radiation de- ite temperature environments as high 2000°F or shock environments in the der of 60g has been announced by n-Lan Electronics, Inc., Santa Monica, l.

The high gain dielectric rod antennas described as the "Lance" series.

Minute aerodynamic cross-section is an ditional advantage of the "Lance" an- nas. Because of their end-fire radia- n characteristics, they can be readily apted to various air-frame configura- ns and parometers.

Designed for general use in ground, rcraft and missile applications, several oduction configurations are used on issiles. The basic "Lance" design is ickly and easily modified in manufacture to fit specific requirements.

The RF characteristics allow the units be supplied with linear or elliptical larization over a frequency range of 00 to 14,000 mc.

Circle Reader Service Card 110

(*Continued on page 92*)

TRANSCO K-BAND DELAY LINE
non-loaded wave guide now in use with missile system

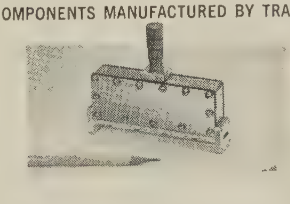
10 x 10 x 20 INCHES

Designed for ground check-out of a missile radar system, this new Transco 47,000 K-Band Delay Line is currently in use with one of the newest missile systems. The unit features two delays that may be remotely selected. Other features include three precision attenuators, two wave guide transfer switches, and a ferrite modulator. Also provided is a variable attenuation bleed line with a directional coupler and monitor crystal.

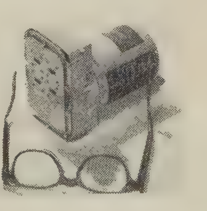
Using these same proved techniques, Transco can supply delay lines for other applications with delays from .01 to 5.0 microseconds at K-Band or other frequencies. Where size reduction is needed, use of the reflective principle or loaded guides can be provided.

Transco specializes in designing, testing and manufacturing microwave components and systems. Write for delay line data sheet.

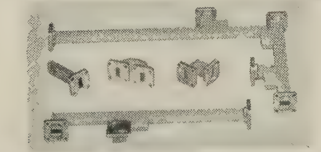
TYPICAL COMPONENTS MANUFACTURED BY TRANSCO FOR THEIR K-BAND DELAY LINE



Precision attenuator,
47150 — 0-70 db range, .3 db repeatability.



Waveguide switch, 47100 —
2 pole transfer, 18-26 KMC,
1.05 VSWR, .07 insertion loss,
80 db crosstalk.



18, 20, 40 db directional couplers,
E-plane and H-plane mitre joints,
high and low power loads.

TRANSCO
PRODUCTS, INC.
12210 Nebraska Avenue
Los Angeles 25, Calif.

COAXIAL SWITCHES
WAVEGUIDE SWITCHES
ANTENNAS
MICROWAVE COMPONENTS
VALVES
ACTUATORS

Circle Reader Service Card 57

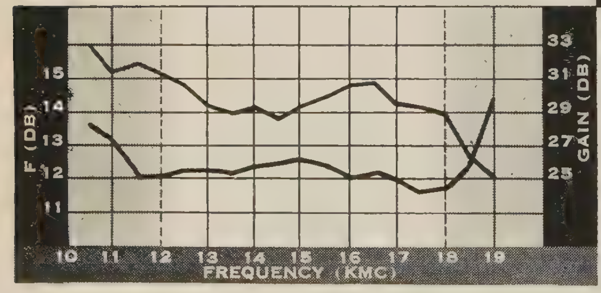
WAVEGUIDE

SPECIALISTS
IN CLOSE
TOLERANCE
BENDING
AND
FORMING

INTASPACE
CORP.
135 ORANGE ST., BLOOMFIELD, N. J.
PIlgrim 8-4700

Circle Reader Service Card 58

Actual test data proves the
Broader Band Operation
of this **HUGGINS TWT**



Test graph of our HA 43, medium noise amplifier tube illustrates how Huggins tubes often perform even better than advertised specifications. Huggins equipment consistently "gives the customer more."

Maximum noise figure here is 12.6 DB for 12-18 KMC and 14.3 for 10.5-19 KMC. Both are well below the catalog maximum of 15 DB. A 25 DB minimum gain is present for an 8½ KMC bandwidth, with greater than 28 DB in the catalog frequencies.
Write us for further information on Huggins TWT's, the industry's most complete line.

HUGGINS LABORATORIES
manufacture
development
engineering
design
research

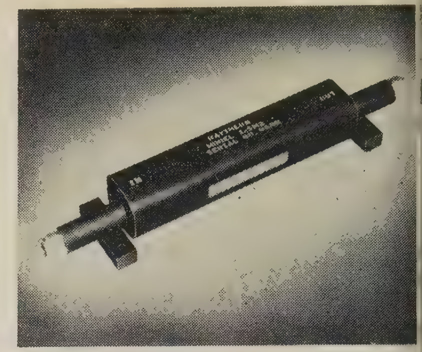
HUGGINS
LABORATORIES INC.
999 East Arques Avenue Sunnyvale, California REgent 6-9330

Circle Reader Service Card 59

New Products

(Continued from page 91)

RAYTHEON PRODUCES TWO NE BROADBAND COAXIAL ISOLATO



Special Microwave Device Operatio of Raytheon Co., Waltham, Mass. h added two broadband coaxial isolato to its product line. The new units, desi nated IcLM3 and IcSM2, open new d sign possibilities in "L" and "S" bar equipment.

The Model IcLM3 operates in tl "L" band region from 1250 to 16(megacycles. Designed to handle pea power of five kw and average of watts, it has minimum isolation of db, a VSWR of 1.25, and insertion lo of 1.0 db maximum. Overall length the 3.8 lb. unit is 12 inches.

The Model IcSM2 covers 2000 to 40(megacycles in "S" band and handles pea power of five kw with an average pow capability of five watts. Maximum isol tion is 30 db with a minimum of 20 d Maximum VSWR is 1.25. Maximum i sertion loss is 2.0 db with 1.0 db poss ble over a narrow band. Overall lengt of the new isolator is 9.8 inches. Weigl is 2.3 lbs.

Both new isolators have Type N f male connectors.

Circle Reader Service Card 111

—mwj—

MICROWAVE REFRACTOMETER DEVELOPED

A direct reading, absolute scale micr wave refractometer has been develope for the West German Armed Forces b Aerialectronics, Inc., Fairborn, Ohio.

The refractometer is a device to mea sure the refractive index of any gaseou material to a high degree of precisio Basically, according to original design b Dr. C. M. Crain at the University o Texas, it makes use of two 10 kmc cavit controlled oscillators: one as a stabl reference and the other as a samplin oscillator. The choice of 10 kmc as a operating frequency permits a direc read-out on a Hewlett-Packard digita recorder, since a change of one part pe million of the reflective index gives change of 10 kc to the frequency of th cavity. When the instrument is cali brated to zero reading under vacuun conditions, it is said to be reading t absolute scale.

Advantages of this development ove relative scale type of instrument are ob

s. Relative scale instruments con- the difference frequency between the oscillators to a voltage for analogue entation, using conventional metering uitry. Amplifiers and discriminators e limited bandwidth and poor sta- ty, so are difficult to calibrate. All olute scale instruments will have a mon reference automatically read to same scale.

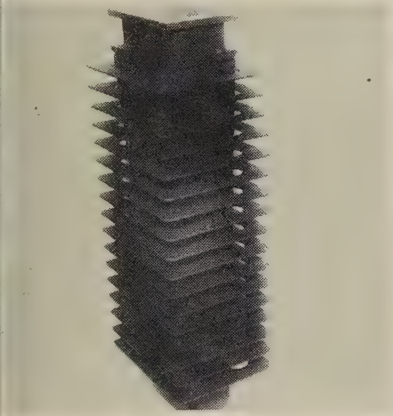
ircle Reader Service Card 112

—*mwj*—

W L-BAND LOAD INTRODUCED BY AIRTRON

 new dummy load introduced for L- d radar by Airtron, Inc., Los Angeles, ., a division of Litton Industries, sipates 8 kw of average power and 0 kw of peak power without liquid ling.

he model 890374 can be used in a quency range of 1120 to 1700 mega- les. Added to the eight other models dummy loads offered by Airtron, it kes possible a choice of dummy loads radar of any frequency from 1120 to 000 mc.



Size of the new model 890374 is 32 7/8 ches long, 8 7/8 inches wide and 7/16 inches high. Weight is approxi- ately 80 pounds. It is compatible with e RG-103/U waveguide, and is de- gned for rugged environmental condi- ons.

A liquid-cooled version also is avail- le for use with significantly higher wers.

Use of inert, high-temperature silicon rbide as the absorptive element mini- izes water absorption, increases sta- lity, and prolongs trouble-free life.

Circle Reader Service Card 113

—*mwj*—

MIDGET MOTOR REVEALED FOR MISSILE USE

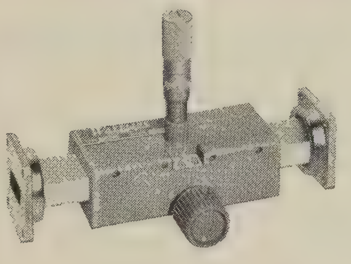
A miniature 1/3-horsepower hydraulic otor for controlling missile antennas they track moving targets was shown ublicly for the first time at the recent rmy Show in Washington, D.C.

The CMF-02 hydraulic servo motor, eveloped by the Bendix Research aboratories, Southfield, Mich., was des- ribed as the smallest motor of its type n existence. Less than one cubic inch n size and weighing only four ounces, t is barely 1/100th as large as a con-

(*Continued on page 94*)

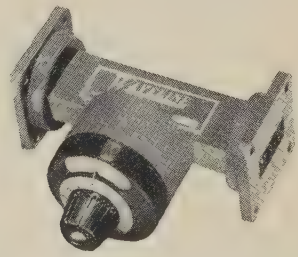
NEW!

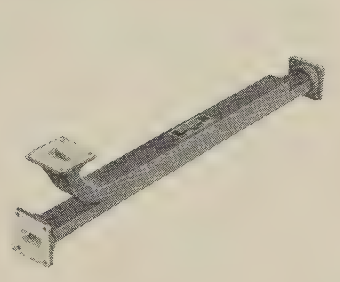
PRECISION WR-51
TEST EQUIPMENT



- PRECISION COUPLERS
- TERMINATIONS
  - High Power
  - Low Power
  - Sliding
- ADJUSTABLE SHORTS
- TRANSITIONS
- SHORTING SWITCHES
- CRYSTAL MOUNTS
- SLOTTED LINES

- ATTENUATORS
  - Flap
  - Variable
  - Precision
  - Direct Reading
  - Fixed Pad
- ELBOWS and TWISTS
- PRESSURE UNITS
- BULKHEAD FLANGES





- VARIABLE SCREW TUNERS
- FREQUENCY METERS
- TEES
  - Shunt
  - Series
  - Magic

Our WR-51 Test Equipment brochure is available on request.

WAVELINE INC.
CALDWELL, NEW JERSEY

CApitol 6-9100

TWX Caldwell, N. J. 703

Circle Reader Service Card 60

SOLID STATE FRONTIERS

New Circulator

- < 0.5 db insertion loss
- 20 db isolation
- 30% bandwidth at C-band

Motorola's new broadband Y-circulator Model CC04 fills a threefold purpose. As a stripline circulator it provides exceptional performance wherever small size and light weight are essential. It also serves as a high-speed electronic switch, acting as a shutter, for example, to protect against receiver burnout resulting from a mismatched antenna. Finally, because of its compact construction, it can be readily cascaded into an integral switching matrix capable of connecting one or more inputs to any one of a number of outputs.

The 3-port circulator, with coaxial connectors, offers 20 db isolation with less than 0.5 db insertion loss over an approximate 30% bandwidth at C-band, a 50% greater bandwidth than has been generally available heretofore.

The microwave characteristics of the switch are identical to those of the circulator. With a compact, transistorized driver, switching times of 10μs have been achieved. Faster switching times are possible with vacuum tube drivers. Utilizing this design, a single-pole, 32-throw switching matrix, complete with drivers, occupies a volume of only 5 x 13 x 19 inches.

REPRESENTATIVE MOTOROLA SOLID STATE DEVICES

ISOLATORS • CIRCULATORS • PARAMETRIC AMPLIFIERS • SWITCHING CIRCULATORS • HIGH-SPEED, BROAD-BAND SWITCHES • PHASE SHIFTERS •

For detailed information, write:

MOTOROLA INC.
Solid State Electronics Department
8201 East McDowell Rd.,
Scottsdale, Arizona WHitney 5-6311

New Products

(*Continued from page 93*)

ventional 1/3-horsepower electric motor. It develops its 1/3 horsepower at 6000 rpm's continuous speed. Displacement is 0.02 cubic inches per revolution.

The new motor is claimed to be ideally suited for missile and satellite applications, where high power requirements are necessary in the smallest space possible. Upon receiving electronic commands through a miniature hydraulic servo valve, the motor can control the missile antenna platform so that it will accurately follow a target's flight, Bendix officials said.

The motor can also be used to control rudders, ailerons and other directional equipment on missiles, aircraft and marine vehicles. It can position directional nozzles on rockets during takeoff and flight, and has applications for many submarine accessory controls.

Actual operation of the miniaturized motor was shown in the research and development booth in The Bendix Corp. exhibit at the Army Show.

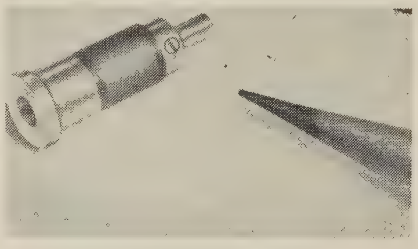
By turning a control knob, visitors at the booth could vary the speed of the motor and observe its operation at both high and low rpm.

Unique design features of the motor enable it to maintain a smooth rather than a pulsing motion, even at low speeds, officials explained. Mechanical parts or components controlled by the motor can therefore be moved instantly and precisely to within a small fraction of a degree.

Circle Reader Service Card 114

—*mwj*—

NEW CRYSTAL RESISTORS DEVELOPED BY FILMOHM



Crystal type resistors that plug into any component normally using the equivalent crystal type have been announced by Filmohm Corp., New York, N.Y. The crystal mounts and mixers can be checked and standardized independently of crystal impedance which can vary from crystal to crystal.

These resistors on IN21 or IN23 crystal bodies are supplied in any resistive value from 25 to 400 ohms with standard 2 per cent or 5 per cent tolerance. Closer tolerance can be supplied on special order.

Made by vacuum depositing a pure metal resistance film on ceramic and immediately sealed by an impervious protective coating, these resistors are extremely stable and reliable. Power rating is one watt average at 100°C.

Circle Reader Service Card 115

TWO SECTION COAXIAL FILTE INNOVATED BY WAVELINE

Waveline, Inc., Caldwell, N.J., a nounces its new model 90116, Two Se tion Coaxial Filter for operation fro 3.5 to 4.0 kmc. This two section filt is individually tuned by precision m

crometer drive to provide a 3 db ban width of 14 mc nominal. The unit ha an input VSWR of 1.25 max. and a insertion loss of 1.3 db max.

The design employs two direct couple quarter wavelength coaxial resonato which are individually tuned for opt mum characteristics. The rejection at F ±30 mc is 22 db minimum. The uni described is intended for laboratory us with the micrometer drive providing a accurate correlation to frequency. Sinc this unit has inherent rugged mechanica design capabilities, it can be modifie to accommodate a screw driver ad justment for frequency so that it ma be adapted for military missile applica tions.

This unit can be furnished with eithe Type N or TNC fittings.

Other designs are available within th frequency range of 2.1 to 5.9 kmc an may be provided with a single gan tuning method of adjustment.

Circle Reader Service Card 116

—*mwj*—

NEW HIGH VOLTAGE VARACTOR FEATURE HIGH Q

Nine new high-voltage silicon varac tor diodes (MA-4380X through MA 4388X) housed in standard subminia ture glass cases with pigtail leads ar available from Microwave Associates Inc., Burlington, Mass.

The series covers a capacitance rang of 0.2 $\mu\mu$fds minimum to 15. $\mu\mu$fds maximum at —6 volts with PIV rating of 30 volts minimum.

Major uses for the new types are in communications equipment, navigational aids, and VHF and UHF transmitters as high-efficiency harmonic multipliers.

These diodes provide substantially increased conversion efficiency and achieve space and cost savings for comparable vacuum tube techniques.

Typical Q of 200-300 at 100 mega- les assures negligible de-tuning of tical RF circuits in RF sweep circuits l in FM deviation or other RF tuning plications. The use of pigtail leads ows convenient soldering.

Circle Reader Service Card 117

—*mwj*—

UGHES DEVELOPS NEW ULTRA-HIGH VACUUM ION PUMP

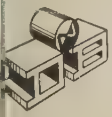
A new line of ultra high vacuum ization pumps has been developed by ghes Aircraft Company's vacuum tube ducts division, Oceanside, Cal., James Sutherland, division manager, has an- unced.

The ion pumps, manufactured in sev- l sizes, contain no moving parts, re- gerators, traps, oils nor heating ele- nts, Sutherland said, "and therefore provide cleaner, drier and more uble-free vacuum pumping for up to 000 hours."

One model in the new line is a com- ct, lightweight six-liter pump that is ly one-fourth the size of conventional its with the same capacity. It pumps the rate of six liters a second, can ieve pressures of less than 10^{-9} mm in either metal or glass vacuum sys- ns, and can be used concurrently as a uum gauge, he said.

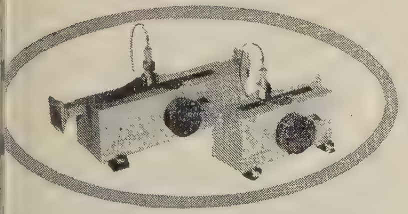
Circle Reader Service Card 118

(*Continued on page 96*)



STANDING WAVE DETECTORS

—exceptionally accurate



You get the accuracy that results rom perfect parallelism between lot and waveguide axis... between robe travel and waveguide axis. Only 30 seconds needed to equip a)-B slotted line to measure adja- ent frequency bands. Range: 5.8 KMC to 140 KMC—covered by a *ninimum* of units, to stretch your udget. Literature on request.

DE MORNAY BONARDI

E MORNAY—BONARDI
0 SOUTH ARROYO PARKWAY • PASADENA, CALIF.

Circle Reader Service Card 62

Choose Your Pursuit From These

FIVE FACETS OF PHILCO IN CALIFORNIA

satellite instrumentation
development of complex, miniaturized instrumentation packages for space probes
space communications
research and manufacture of space and ground equipment providing command functions, data transmission, reception
range design and operation
engineering, installation and operation of complete tracking station facilities world-wide
data processing
conversion, analysis, presentation and storage of data received from space vehicles
missile tracking
design and development of complete facilities for collecting orbital data on advanced satellites

A PLACE FOR YOU awaits at rapidly expanding Philco Western Development Laboratories on the San Francisco Peninsula, where new concepts of space communication offer exceptional opportunities to the exceptional engineer . . . with proportionate rewards. Your experience and your interests determine your assignment at PHILCO in the development of the complete system — from the space communication network of space vehicles to the complex data processing equipment of the ground station complex.

For you . . . the opportunity of graduate study on a Tuition Refund basis at any of the excellent surrounding educational institutions, liberal employee benefits, and the facilities of Philco's new, modern R & D laboratories.

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Immediate openings now exist for graduate engineers with experience in equipment design, systems engineering, analysis and integration. As a first step toward expanding your skills at Philco, send your resumé in strict confidence to Mr. W. E. Daly, Engineering Placement.

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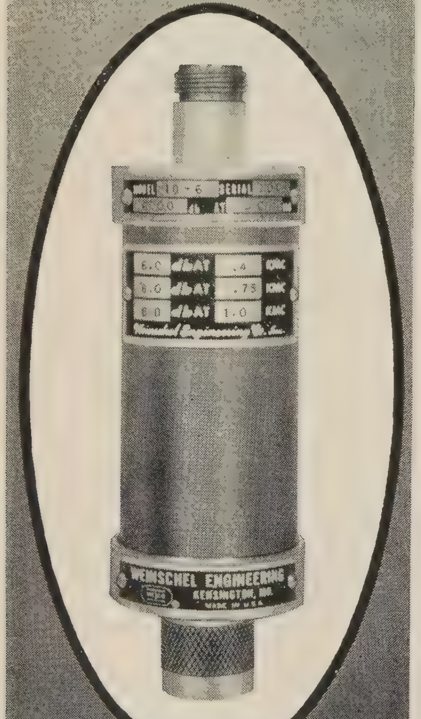
WEINSCHEL

10 WATT
POWER PADS
Model 10

DC to 1 KMC
Attenuation: 1 to 20 db
50 Ohms

- Connectors: Type N, 1 male, 1 female
- High stability, low frequency sensitivity
- Power Sensitivity: Less than .1 db/10 watts
- Calibration Frequencies: DC, 400 mc, 750 mc, 1000 mc
- Finish: Stainless steel connectors; black anodized aluminum body



Model 10

Complete specifications upon request.

® WE CO

Weinschel Fixed Coaxial Attenuators cover the frequency range of DC to 12.4 KMC. Write for complete catalog.

Weinschel Engineering
KENSINGTON, MARYLAND

Circle Reader Service Card 64

New Products

(Continued from page 95)

PORTABLE TRANSPONDER FUNCTION TESTER AVAILABLE

The Wilcox Electric Company, Inc., Kansas City, Mo., has announced the development of an extremely simple go-no-go transponder function tester to be used in ground checkout of installed transponders, such as the AN/APX-44, according to a company spokesman.

The unit, designated model 860A Portable Function Tester, is hand-held near the transponder antenna of an aircraft. The signal produced, when the unit is triggered from within a foot or two of the antenna, activates the aircraft transponder and the activation of a lamp on the portable function tester indicates whether the transponder has transmitted a responding signal. Tester operation provides a check for receiver sensitivity and transmitter output in addition to a partial check of decoder-encoder performance.

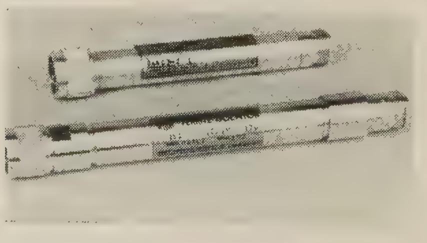
Package design and transistorized circuitry make possible a test set which permits high speed checks on an individual or fleet basis with a minimum operator-training time and maintenance.

The tester, which weighs less than four pounds, operates from four self-contained standard 1 1/2-volt "D" batteries. The high impact housing makes the unit virtually indestructible.

Circle Reader Service Card 119

—mwj—

SPERRY ANNOUNCES FIRST MINIATURIZED COAXIAL ISOLATORS



Sperry Microwave Electronics Co., Clearwater, Fla., has announced the development of a complete line of miniaturized coaxial line isolators with no external permanent magnets.

These units can be designed for op ation from UHF to X-band regions. T three basic units designed for operati at C, S, and L-band, and designated models D44C7, D44S7, and D44L7, spectively, operate over 10 per cent ban widths and provide more than 15 isolation and less than 0.9 db inserti loss. The respective bandwidths co ered by the isolators are 5.4 to 5.9, 2 to 3.1, and 1.25 to 1.35 kmc.

The isolators measure only 3/4 inch diameter, and the lengths vary from 4 1 inches for the C-band unit to 6 5 inches for the L-band unit. Respecti weights of the units are 4, 5, and ounces each.

In principle, the isolator design based on the early work performed Sperry. The techniques which enabl achievement of the unusually small si have been used in the achievement some 30 other designs in the range fr .96 to 6.0 kmc.

Potential applications for these min turized isolators include their use missile and aircraft equipment; te metry, radar, and communications s tems; and laboratory applications. Th primary advantages are their extreme small size and weight, excellent elect cal performance and almost 100 per ce magnetic shielding. The application external magnetic fields of several hu dred oersteds exhibits negligible effect the electrical performance of these uni

The three models indicated are ava able for delivery from stock in sm quantities, or in production quantit with delivery beginning 30-60 days aft order. They are also available in oth frequency bands on special order. Pri of these models are $225, $225, and $2 respectively.

Circle Reader Service Card 120

—mwj—

RADAR TRANSPONDER INTRODUCED BY AERO GEO ASTRO

ANT
PRES. TUNE

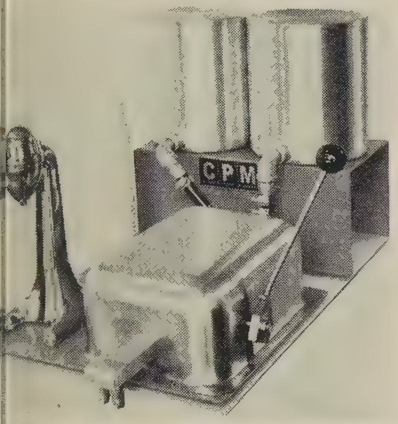
The AGA C/T Mod 2 Radar Tra ponder, a transistorized unit for airbor applications compatible with present d instrumentation radars similar to A FPS-16 and AN/MPS-26, has been int duced by Aero Geo Astro Corp., Al andria, Va.

Its small size, 92.6 cubic inches, l weight, 5.75 pounds, plus its low pow consumption and ability to operate missile environment make it an ideal strument for many varied purposes. T electrical characteristics represent sup rodyne sensitivity, single or double se interrogation, and a 400 watt transter output. A solid state modulator is rporated with recovery time on the er of 160 μs.

Circle Reader Service Card 121

—*mwj*—

EPOXY AND POLYURETHANE DISPENSING FACILITATED



The Multi-Rez-Processor, manufactured CPM Special Machinery Corp., Brook- N.Y., presents the first opportunity get into production with reactive n mixes at low initial cost.

simplifies the use of two part epoxy polyurethane compounds. The unit proportion, dispense, and mix multiponent reactive resins. Proportional uracy of the two component media pensed is maintained through mechanical linkage operating positive displacement pumps.

Thorough blending of the resin mix is accomplished by a powerful motorized mixer. The teflon impeller is the only part of the Multi-Rez-Processor which enters the reactive resin mix. There are no cleaning or purging problems as it is impossible for this equipment to freeze up. Short pot-life resin mixes can be handled with ease and safety. This equipment is sold as a packaged unit and is shipped completely assembled from the reservoirs to the dispenser and is ready to run.

Circle Reader Service Card 122

—*mwj*—

NEW MICROWAVE POWER SUPPLIES DEVELOPED BY ALFRED ELECTRONICS

Capable of operating virtually all presently known low and medium noise figure TW tubes, two new Microwave Power Supplies have been developed by Alfred Electronics, Palo Alto, Cal., for either local or remote operation of TW tubes.

Alfred's model 252, providing all normally required electrode sources in one instrument, is especially suited for powering permanent magnet focused TW tubes. With the addition of a solenoid supply, the combination model 252/253 will operate electromagnet focused TW tubes. Model 253 includes space to

(*Continued on page 98*)

OPTICAL MASER RESEARCH

A challenging opportunity exists for a man who can take charge of a research program on light amplification and related fluorescence studies.

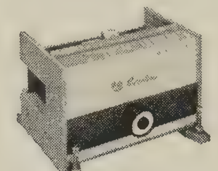
The man we are looking for is a microwave engineer, physicist, or a physical chemist with a Ph.D. degree or equivalent experience.

The position is in a new field of interest for Corning Glass Works, a 108-year-old firm recognized for its pioneering research achievements. The company's new modern laboratories are situated in the beautiful Finger Lakes region of New York State.

For full information, write to Mr. James L. Knapp, Staff Manager, Research and Development Division.

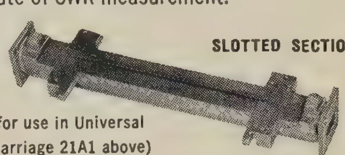
CORNING GLASS WORKS
CORNING, NEW YORK

SPERRY Microline®
highly accurate
IMPEDANCE INSTRUMENTS



UNIVERSAL CARRIAGE 21A1

This carriage is machined to a high degree of accuracy and carefully designed for long life and low wear of parts. Extreme rigidity and factory adjustment assure precision travel of probe within waveguide walls enabling the most accurate of SWR measurement.



SLOTTED SECTIONS
(for use in Universal Carriage 21A1 above)

These sections fit precisely into the Microline 21A1 Universal Carriage assuring perfect positioning with respect to travel of the probe tip. Each slot is tapered at both ends to reduce secondary slot effects.

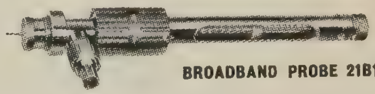
SPECIFICATIONS

Model	Frequency Range Kmc	Price
21A1 (Universal Carriage)	3.95-18.0	$160
21C1	3.95-5.85	110
21G1	5.2-8.2	110
21H1	7.05-10.0	110
21X1	8.2-12.4	90
21U1	12.4-18.0	110

Residual VSWR (Max), 1.01

SLOTTED LINES

These are precision built units for applications in S and L bands, machined and manufactured to the same fine tolerances as the 21A1 Universal Carriage. Precision slotted waveguide casting is integral with the carriage.



BROADBAND PROBE 21B1

For use with all of the above units we recommend the Microline 21B1 Broadband Tunable Probe. This probe is outstanding because of its unique dual action repeatable tuning adjustments, and its complete freedom from any type of erratic operation.

SPERRY

SPERRY MICROWAVE ELECTRONICS COMPANY,
Clearwater, Fla., Division of Sperry Rand Corp.

TRAK
TRAK ELECTRONICS COMPANY

NEW REDESIGNED AND EXPANDED LINE OF MINIATURE OSCILLATOR CAVITIES

from 800-7000mc by
TRAK ELECTRONICS COMPANY

From its twelve years of research, development and experience with microwave oscillator cavities, TRAK now announces two new standard cavities:

(1) TRAK Type 9127-C for C-Band Pulse Service, 5400-5900 mc, pictured above.

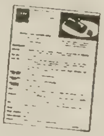
(2) TRAK Type 9127-S for S-Band Plate or Grid Pulse Service and as a CW oscillator, operating in any 300mc part of 2700-3600mc.

Other cavities engineered to customer specifications, 800-7000mc.

TRAK cavity Type 9127-C is shown above and its specifications are:

Frequency	Tunable from 5400—5900mc. Tuning done by adjusting a screw located on one end of the cavity.
Tube Type	G. E. 7486.
Power Out	Greater than 50W peak minimum over the band. (0.002 duty cycle, 1 microsecond pulse, 1000 volt pulse at approx. 0.7 amps. Higher powers obtained by using higher pulse voltages.) Depending upon the individual tube, output powers exceeding 100W peak have been obtained.
Output Pulse Rise Time	Less than 25 millimicroseconds.
Leading Edge Jitter	Approx. 5 millimicroseconds.
Temperature Stability	±0.05% from 0°C. to +71°C.
Shock	100G for 7 milliseconds in each of 3 major axes results in less than max. ±0.25mc. FM.
Vibration	15G from 50 to 2000cps. in each of 3 major axes results in max. ±1mc FM. Cavity survived 56G at 2000 cycles with less than ±4 mc FM.
Size	1″ diameter x 2½″ long, excluding output connector and mounting brackets.
Weight	4 ounces.
Output Impedance	50 ohms.
Output Connector	Type TNC.
Mounting	Engineered to customer specifications.

We invite you to write for TRAK Cavity Technical Bulletins.



TRAK ELECTRONICS

MICROWAVE COMPONENTS DEPT.
TRAK ELECTRONICS CO.
Division of CGS Laboratories, Inc.
55 Danbury Road, Wilton, Conn.
Tel: POrter 2-5521

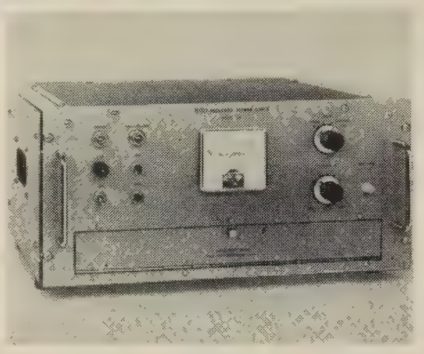
Circle Reader Service Card 67

New Products

(*Continued from page 97*)

mount a TW tube and solenoid for local operation.

For remote operation of TW tubes — in low noise broadband preamplifier applications, for example — an extra wide voltage range of the heater and solenoid supplies compensates for IR drop due to long interconnecting cables.



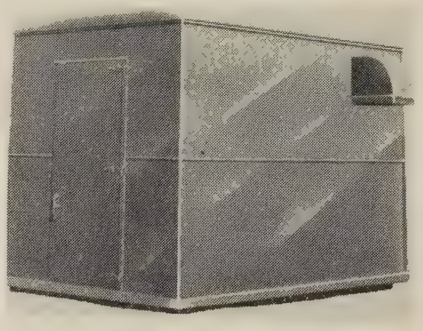
Both models are extremely simple to operate, with all controls needed for normal use mounted on the front panel. TW tubes may be operated in any of three ground arrangements. The 50 to 450 cps input power range permits use with almost any available power source.

Well-regulated electrode supplies, carefully designed for minimum drift, assure stable operation of the microwave tube. Use of DC heater voltage reduces spurious amplitude modulation.

Circle Reader Service Card 123

—*mwj*—

FACTORY PRE-BUILT MICROWAVE BUILDINGS AVAILABLE



Engineers of the Tower Construction Co., Sioux City, Iowa, have developed a factory pre-built building that offers all the advantages of a permanent building plus factory built-in features.

These special features include such items as wiring and insulation which are installed prior to shipment.

The new-type building, the only one ever developed exclusively for use with microwave equipment, is currently being used at tower sites by several pipe line companies and public utilities.

The Tower factory pre-built, with a tough metal jacket, can be delivered to the site on trucks or delivered by rail. Field installation requires minutes rather than days and eliminates expensive delays which were encountered frequently when the old type building had to be built in the field.

Intricate microwave equipment wh
formerly had to be installed in the fie
often with the help of inexperien
local labor, can now be pre-installed
the factory by experts. Simple field t
ing is all that's required to make
unit entirely operational.

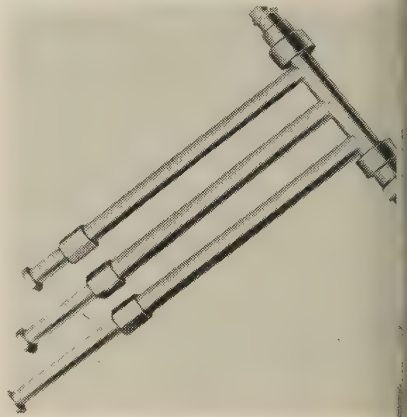
Circle Reader Service Card 124

—*mwj*—

COMPLETE LINE OF STUB TUNE ANNOUNCED BY MICROLAB

A new line of coaxial stub tuners
been announced by Microlab, Livingst
N.J. Included is a complete selection
single, double, and triple stub tun
with a wide variety of frequency ran
and connector combinations.

These tuners cover the frequency ra
from 200 mc to 12,000 mc in three ov
lapping bands. They have been desig
to match a wide range of impedan
with good convergence and tuning se
tivity. Beryllium copper contacts



used for long life and noise-free ope
tion. Locking caps are provided to adj
sliding tension and to lock the desi
settings.

The tuners are provided with one m
and one female connector in either
N, BNC, TNC, C or HN series. Th
are ruggedly constructed to meet m
tary specifications and will operate fr
—55° to +150°C.

Tuners with single, double, or tri
stubs are available for immediate d
very from stock. The price is depend
upon the frequency range and connec
type and is between $40 and $60 for
single stub, $90 and $140 for
double stub, and $140 and $180 for
triple stub.

Circle Reader Service Card 125

—*mwj*—

MACHLETT ANNOUNCES HIGH VOLTAGE TRIODE

A new high-voltage triode that
switch 150,000 volts in pulse modulat
for radars and other electronic switchi
applications has been announced by
Machlett Laboratories, Inc., Springda
Conn., a subsidiary of Raytheon Co.

The oil-cooled ML-7668 has dc pl
and inverse voltages of 150,000 vo
and a peak cathode current of 6.5 am
Dissipation of grid and plate are 50 a
750 watts, respectively. At 150,000 vo

ut-off grid voltage is in the order of -900 volts. lament voltage is 12.6 volts and ment current is approximately 29 s. The new triode measures 11 5/8 es high with a 5 1/8 inch diame-

ircle Reader Service Card 126

—*mwj*—

HIGH RELIABILITY RF CONNECTORS DEVELOPED

esigned for use with small size coax- cables, such as RG-59 B/U, a new es of "AN/MS" Type connectors de- ped by National Connector Corp., neapolis, Minn., is the first avail- line of connectors of this type to use diated polyolefin and polypropylene. itherproofed and designed for extreme reliability, even under abnormal conditions of stress, NCC's "AN/MS" series connectors may be efficiently used up through microwave frequencies with a minimum of line unbalance or increase in standing wave ratio. Unique design permits the coax conductor to be soldered directly to the contact point within the connector body, greatly reducing the danger of accidental disconnection due to cable strain.

Circle Reader Service Card 127

—*mwj*—

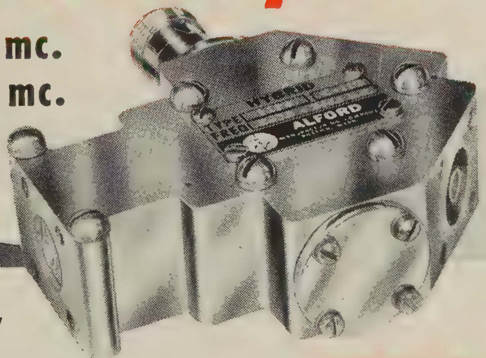
NEW 15 MC OSCILLOSCOPE AVAILABLE FROM HEWLETT-PACKARD

A highly versatile, 15 mc oscilloscope built to exacting military specifications is now available from Hewlett-Packard Co., Palo Alto, Cal.

The new oscilloscope, model 160B, is a rugged, dependable instrument meeting requirements of MIL-E-16400B for shock, vibration, humidity and temperature. Premium components are used throughout the instrument, and its high stability tube-transistor circuits assure long life and reliability.

Model 160B's versatility is enhanced by a series of newly-designed time axis plug-in units. These include the model 166C Display Scanner, which provides the scope with an X-Y recorder output. This output utilizes the full scope bandwidth capability and makes possible

(*Continued on page 100*)



AMCI

NOW

S BAND HYBRIDS

at a new low price

1600-2400 mc.
2400-3600 mc.

- Balance inherently independent of frequency
- Handles high power
- Constant coupling in both magnitude and phase over the frequency range with equal loads

$275.00

Type	Frequency range	Residual unbalance (isolation)	Price
1102	1600-2400 mc	greater than - 40 db	$275.00
1104	2400-3600 mc	greater than - 34 db	$275.00

Type 1104-S Hybrid for use over the frequency range 2200-5000 megacycles is also available. It has the same low residual unbalance but a higher SWR.

Write for complete information on AMCI Transmission Line Hybrids

ANTENNA SYSTEMS – COMPONENTS – AIR NAVIGATION AIDS – INSTRUMENTS
AMCI ALFORD *Manufacturing Company*
299 ATLANTIC AVE., BOSTON, MASS.

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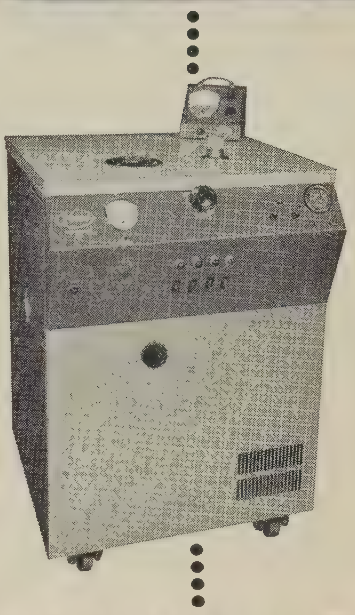
QUALITY WITHOUT COMPROMISE
Performance
Flexibility
Reliability



PACKAGED LEAK TEST STATIONS

VEECO's MS-9 leak test consoles are packaged stations with guaranteed constant sensitivity. The helium mass spectrometer permits hermetically sealed units to be *certified* leak proof at a sensitivity of 10^{-10} std. cc/sec.

VEECO manufactures a complete line of high vacuum equipment... Components, Leak Detectors, Evaporators, Systems... accepted as the *quality* line for over a decade.

*For MS-9 Brochure or Complete Catalog write Dept.***

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VACUUM-ELECTRONICS CORP.
Terminal Drive • Plainview, L. I. N. Y.
HIGH VACUUM & LEAK DETECTION EQUIPMENT

Circle Reader Service Card 69

New from CFI
ceramics for industry
Stable at 1,000 degrees Centigrade

High-Power Microwave Absorber Ceramics

From CFI's fully integrated ceramics service come the new 1000 Series microwave absorber ceramics.

Typical performance from 1000 Series ceramics shows exceptionally high losses of 9.05 db/cm at 25 deg. C. and "uniform" attenuation over an extremely wide range of frequencies. What's more, these new microwave ceramics are stable in air or vacuum at high temperatures in excess of 1,000 deg. C. in both low and high power systems.

For complete details on the 1000 Series and other custom-designed ceramics and ceramic-to-metal composites for your precise microwave specifications, call CFI today.

Send for free
CFI ceramics data

CFI *An Integrated Ceramics Service*

CFI Corporation
Department MJ, Cottage Place
Mineola, New York—Pioneer 6-0571

Gentlemen: Please send me, without obligation, the following literature on CFI ceramics:

☐ "Custom Ceramic Parts for Industry" Brochure
☐ Microwave Ceramics Spec Sheet
☐ Have technical representative contact me.

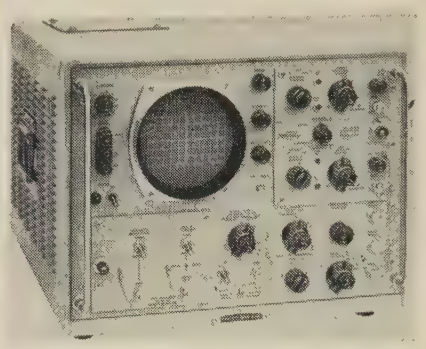
Name__________
Title__________
Company__________
City______Zone____State____

Circle Reader Service Card 70

New Products

(*Continued from page 99*)

large, high resolution, permanent X-Y records of repetitive waveforms. The model 166D Sweep Delay Generator, another time axis plug-in, provides the standard sweep delay functions and in addition has a unique mixed sweep function which allows observation of low speed and high speed phenomena on the same trace.



New vertical amplifier plug-ins include the model 162A Dual Trace Amplifier, (20 mv/cm sensitivity) permitting simultaneous viewing of two phenomena or differential amplification of signals dc to 14 mc.

The model 160B scope provides 24 calibrated sweep times, 0.1 microsecond/cm to 5 seconds/cm, with ±3 per cent accuracy. A sweep magnifier increases the fastest sweep to 0.02 microsecond/cm. Horizontal amplifier sensitivity is 0.1 v/cm to 10 v/cm.

The new scope has simple, logically grouped controls and features an automatic beam-finder and improved preset triggering. The instrument is priced at $1850 and its current availability is 13 weeks. The model 162A Dual Trace Amplifier is priced at $350; current availability is 13 weeks.

Circle Reader Service Card 128

—*mwj*—

NEW FXR COAXIAL COUPLERS MEASURE VSWR

FXR, Inc., Woodside, N.Y., manufacturer of microwave and other electronic equipment, has developed two coaxial broadband bidirectional couplers particularly suited for measuring VSWR by the incident and reflected power technique.

The two models, N616D and N617D, are also excellent for making power and frequency measurements and serve as accurate and stable standards of attenuation. Because of their ability to absorb a minimum of one watt of cw power, they are ideal for injecting large values of local oscillator power into a mixer circuit. They have good directivity and uniform coupling over a range of two octaves.

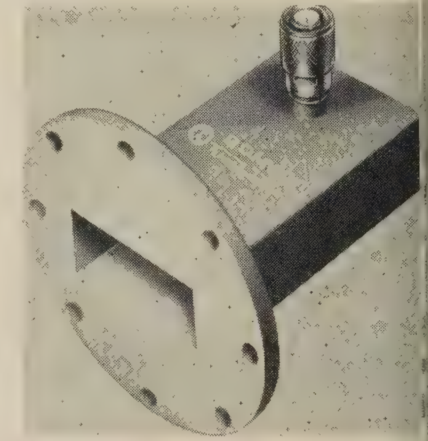
The frequency range of FXR moc N616D is from 0.25 to 1 kmc, a model N617D from 1 to 4 kmc. nominal coupling value of 20 db includ the effect of the low-reflection termin tions in the secondary arms and reflecti from the connectors. Calibration curv showing the incident and reflected ar coupling, are attached to the body the component. Main line VSWR is le than 1.02 and the auxiliary arm VSWR less than 1.25.

Circle Reader Service Card 129

—*mwj*—

NEW MICROWAVE COMPONENT TESTS BOMAC BEACON MAGNETRONS

A new device for assisting in the tes ing of Bomac Beacon Magnetrons, th Coaxial Line-to-Waveguide Transitio has been developed by Bomac Labor tories, Beverly, Mass. These transitio present a maximum VSWR of 1.10 ov



the specified band, and can be used t excellent advantage in circuits whe usually available units present excessiv reflections.

The four transitions are available i six models, with frequencies rangin from 5.2 to 9.5 kmc.

Circle Reader Service Card 130

—*mwj*—

NEW SYNCHRO TRANSMITTER UNITS INTRODUCED

A new series of synchro transmitter uni featuring a wide selection of input ratio high accuracy, and small size have bee introduced by Scientific-Atlanta, Inc., A lanta, Ga.

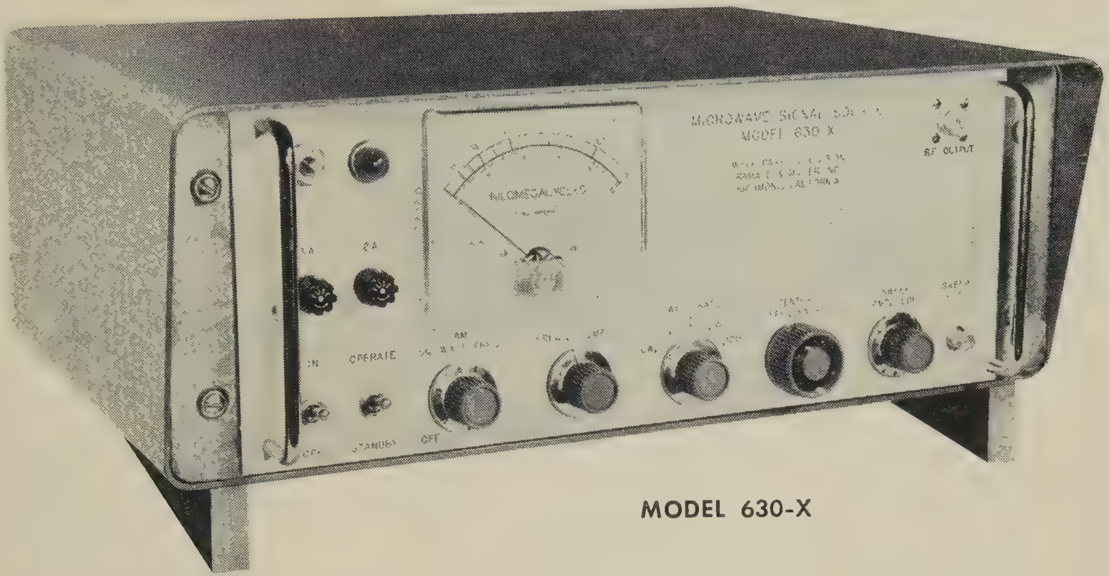
The Atlanta firm's Series PX-1 units sup ply linear or angular position informatio devices such as industrial control system to a remote location from electro-mechanic automatic machinery, antenna pedestals, an missile or satellite tracking systems. Th units consist of either one or two Typ 23TX6 synchro transmitters geared to shaft at different ratios to give maximu flexibility of installation.

The standard two-speed unit has on synchro geared 1:1 and the other geare

(*Continued on page 102*)

NEW

ECTRONICALLY SWEPT SIGNAL SOURCE



MODEL 630-X

VAVE PARTICLE offers a com-
ete line of electronically swept
icrowave signal sources which
over the entire frequency range
om 0.98 to 75.0 KMC. Uniquely
ngineered and designed, the in-
truments combine truly remark-
ble features that satisfy the most
emanding requirements.

MODEL 630-X
8.2 - 12.4 KMC

Power Output . .	20 mw. (minimum)
Sweep Rate . . .	C.W. or 0.1-100 CPS
Sweep Width . .	A Few MC. to 4.2 KMC
A.M. Modulation .	800-1200 CPS Square Wave
Sweep Output . .	Linear Sawtooth
Oscillator . . .	Varian VA-161
Price	$2,850.00
Delivery	2-4 weeks

- ▶ LIGHT WEIGHT, ONLY 28 LBS.
- ▶ SIMPLE TO OPERATE. A MINIMUM OF CONTROLS SIMPLIFIES OPERATING PROCEDURE
- ▶ COMPACT DESIGN. ONLY 7″ x 19″ PANEL AREA.

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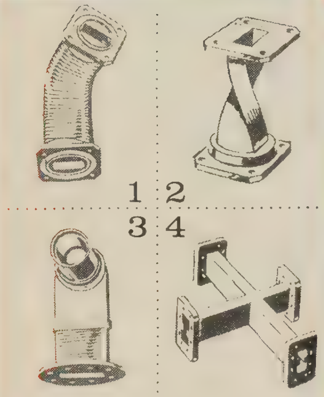
Circle Reader Service Card 71

MICROWAVE

BUILDING BLOCKS
FOR THE SPACE AGE
by
ELECTRONIC
SPECIALTY CO.



1 **FLEX WAVEGUIDE ASSEMBLIES**
Electrical Characteristics
Operation .... 12.4 to 18.0 kmc
Attenuation .... 0.16 db/ft.
VSWR .. . . 1.08 max.
Bend Radius
E Plane ..... 5/16 inch; 5/8 with jacket
H Plane ....1/2 inch; 1.0 with jacket
Mates .... RG - 91/U
Weight . . .. 1.002 lbs./Ft. (bare)
Operating Pressure ... 30 PSIG max.
Equivalent
Flanges .... Plate (UG-419/U)
Choke (UG-5 A/U
Other Standard Sizes Available

2 **RIGID WAVEGUIDE ASSEMBLIES**
ID Size Range .....From 0.420 x 0.170
to 6.50 x 3.250
Frequency .... From 1.12 to 26.5 kmc
Rigid Waveguide assemblies are furnished either straight or in a variety of configurations, including system plumbing.

3 **WAVEGUIDE TO COAX TRANSITION**
Frequency Range ... 2350 to 3600 mc
Power .... 800 watts cw
VSWR .. .. <1.2:1
Insertion Loss .... <0.25 db
Coaxial Impedance ...... 50 ± 2 Ohms

4 **POWER DIVIDERS**
Frequency Range 4.7 to 11.0 kmc
VSWR..... . ... 1.4:1
Power
Split ...... +0.5 db (4.7 to 11.0 kmc)
Power .... 400 watts average
Altitude .... >60,000 feet
Meets MIL-E 5272-A and MIL-E-5400

ES development engineers welcome the opportunity to furnish an engineering estimate on your specific requirement. Emergency circumstances given special consideration. Ask for the TECHNICRAFT design folder.

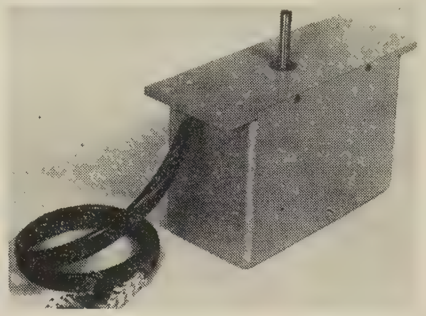
TECHNICRAFT
DIVISION
ELECTRONIC SPECIALTY CO.
CORPORATE OFFICES:
5121 San Fernando Road
Los Angeles 39, California
CHapman 5-3771

Circle Reader Service Card 72

(*Continued from page 100*)

36:1 in relation to the shaft motion to be monitored. The 1:1 synchro provides the non-ambiguous signal while the 36:1 synchro provides the high accuracy signal.

System accuracies range from 0.05 per cent to 0.01 per cent depending on the particular installation. Units may be readily modified for special applications.



Position information signals from Series PX-1 units will drive Scientific-Atlanta Series PI 2 and PI 3 position indicator units, Series APR antenna pattern recorders, the Model API antenna pattern integrator, and other servo-controlled instruments.

Circle Reader Service Card 131

—*mwj*—

LOW NOISE WIDEBAND RF AMPLIFIER AVAILABLE

Applied Research Inc., Port Washington, N.Y. announces the availability of a new RF amplifier, designed for outdoor applications, and providing moderately wide band amplification at a low noise figure.

Designated as Model UH-2(A)SPC, the equipment is mounted in a splashproof case which may be used at the base of an antenna mast, or on the mast itself with suitable mounting arrangement. Power supply is self contained.

Frequency range may be at any center frequency between 30 mc and 300 mc, with bandwidths up to 10 per cent of center frequency and gains greater than 20 db. Noise figures range from less than 1 db at 30 mc to less than 3 db at 300 mc. Gain and noise figure are functions of bandwidth and frequency.

Size of case is 16-1/8 inches long x 9-1/4 inches wide x 7 inches high. Weight is 16 lbs. Delivery is 45 days. Further information including price will be sent on request.

Circle Reader Service Card 99

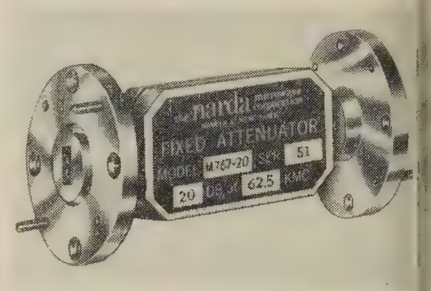
—*mwj*—

NEW PRECISION FIXED ATTENUATORS ANNOUNCED BY NARDA

A new Precision Fixed Attenuat which provides, in an extremely sho calibration with little variation over t length, flat response and highly preci whole frequency range, has been a nounced by the Narda Microwave Co poration, Mineola, L.I., N.Y.

The attenuation is relatively insensiti to frequency variation, and calibratio is permanently stable and independent environment. Calibration at 5 freque cies: ±0.1 db accuracy; mean attenu tion is ±0.3 db from nominal; variatio across band is ±0.5 db.

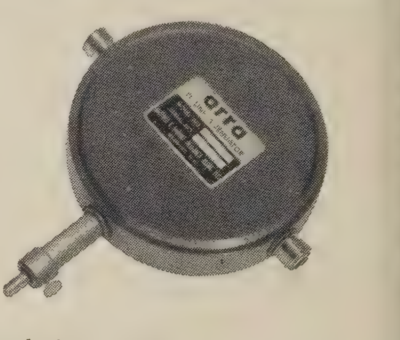
The short-length design and high a



curacy featured in Narda Precision Fixe Attenuators is made possible by Narda use of a molded lossy ridge. The sma size, elimination of fragile termination

(*Continued on page 108*)

arra π LINE CONTINUOUSLY
VARIABLE ATTENUATOR



Exclusive Features:

- Broadband Impedance Match.
- Min. VSWR for all values of attenuation over band.
- Insertion Loss: 0.2 db max.
- Drive: Shaft drives for systems & power level applications.
- Connectors: Type "N" Female (others on request).
- Size: 5" dia. x 1" high, excluding connectors and micrometer.
- Power Rating: 10 watts average min.
- Continuously variable for all values of attenuation.

Write for Information — Dept. P-IRE

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27 BOND STREET • WESTBURY, N. Y.

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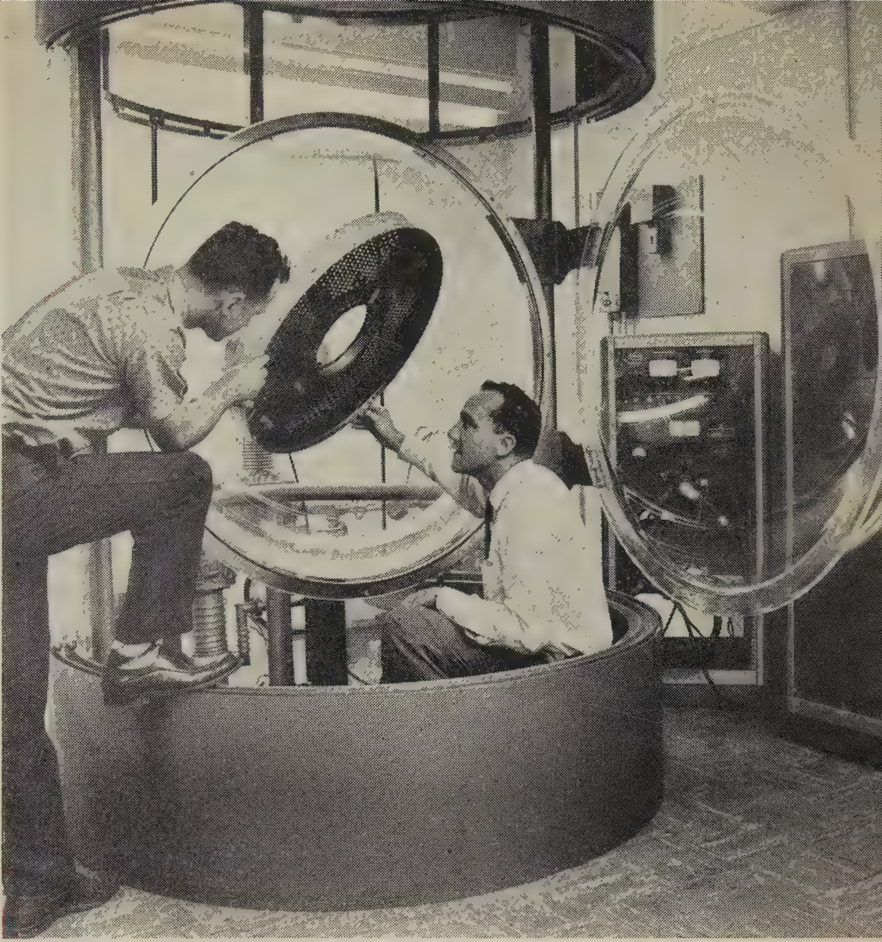
COMPANY PROFILE

OCKHEED

Missiles and Space Division

SUNNYVALE, CALIFORNIA



A. W. Ward and A. F. Gaetano inspect a telemetry antenna being readied for test in the vacuum chamber.

ectromagnetics

At every stage, from concept to operational hardware, e success of the United States missile and space pro- am is completely dependent on the development of iable and highly sophisticated instrumentation and mmunications systems. Consequently, as prime con- ctor for the Navy's Polaris Fleet Ballistic Missile and e Air Force's satellite programs — Discoverer, Midas d Samos — as well as NASA's earth satellite and deep ace missions, the Lockheed Missiles and Space Division deeply involved in advance electronic research and oduct development. In this general area, some of the ost advanced work is being done in the field of elec- omagnetics under the direction of E. A. Blasi, manager the Electromagnetics Division of the Research and evelopment Branch.

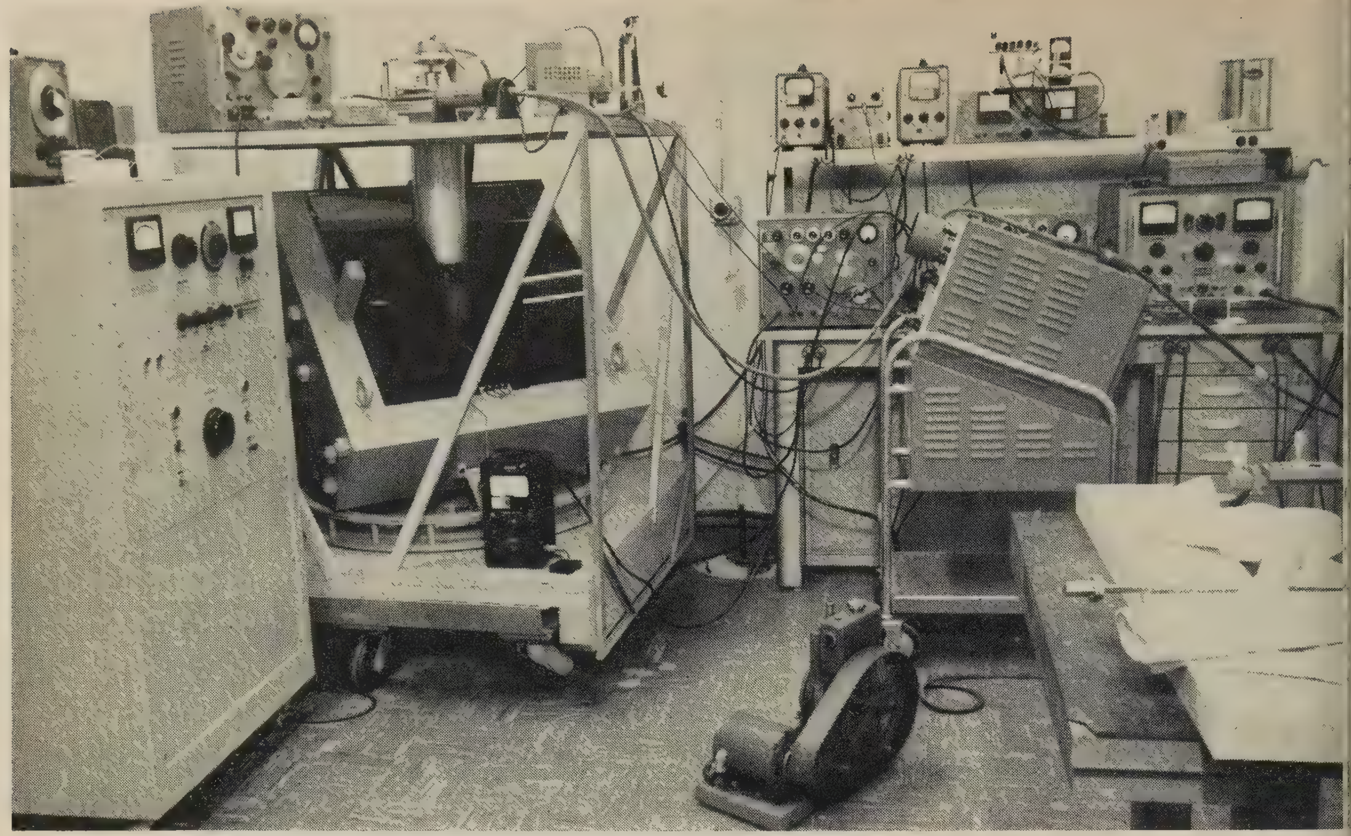
Visitors to his organization are greatly impressed with e broad scope of activities, equipment, and personnel at they see gathered together in this one laboratory. ere "Electromagnetics" means everything in space com- unications and tracking between the transmitter output d the receiver's i-f amplifier input — and occasionally ere is pressure to expand these boundaries a little. rthermore, activities run the gamut from pure research end-item design. There is, however, a remarkable in- gration of all effort within this field. Mr. Blasi explains this way. "The greatest asset we have is the strong erplay between research work and its application to d-item development. Rather than having a split be- een research and development, here we integrate these interests in coming up with the elements of successful communication and tracking links."

While there are no barriers between research and development people, they are, in fact, organized into two departments: Electromagnetics Research, which concentrates on company-funded general research, sponsored research and applied research in support of the major LMSD projects; and Microwave Applications, which is primarily responsible for the design of all antennas, r-f components, and r-f systems used in the Polaris and Satellite Systems vehicles.

Research Activities

A. S. Dunbar, Manager of Electromagnetics Research, divides his department's work into three principal areas: (a) ionized gases and their effects on electromagnetic wave transmission, radiation, and reflection; (b) electromagnetic wave scattering, diffraction, and polarization; and (c) radio propagation phenomena, with special emphasis on space vehicle tracking and extra-terrestrial sources. Within these areas, the spectrum of research effort extends from the study of new antenna design concepts to highly theoretical studies in diffraction, and from practical studies in ionspheric radio propagation to mathematical analyses of electromagnetic wave propagation through shock-heated gases.

Research on the interaction of electromagnetic waves and ionized gases centers around two chief aspects of missile atmospheric re-entry — blackout of telemetry sig-



A 2250 mc maser setup — an example of Lockheed microwave circuits research.

nals caused by the sheath of ionized gas around the missile and its antennas, and the radar reflectivity of the ion sheath and the ion trail. The telemetry study has been mainly theoretical, collecting and interpreting basic data from the diverse fields of aerodynamics, thermodynamics, plasma physics, and antenna design. One product of this study consists of predictions of telemetry system performance for various frequencies and missile trajectories which are turned over to the instrumentation system designers of the Polaris and other projects to become the basis for their equipment specifications. The reflectivity study, on the other hand, has been largely experimental. Working with the LMSD Gas Dynamics Department, the group in Electromagnetics Research is carrying out experiments in the "Hot-Shot Tunnel" at the Palo Alto plant. This apparatus is a hypersonic wind tunnel in which the discharge of a large capacitor bank sends a wave of air past a model at re-entry speeds while microwave instruments record the resultant ionization around and behind the model. This formation is principally of interest in the design of down-range instrumentation. R-F discharge on antennas in the upper atmosphere is being studied in the laboratory, as well as the effect of ambient ionization on the initiation and extinction of the discharge.

Two important current efforts can definitely be called pure research in electromagnetic theory — the study of diffraction being led by Nelson Logan and the study of polarization characteristics of radar targets being led by "Rick" Huynen, Mr. Logan has examined the historical aspects of his subject critically in coordinating the classic work of approximately fifty theorists into a unified treatment. As he explains, "A single paper hasn't been published without its essential contribution having been covered." Technically speaking, the work is an explora
tion of the functions which satisfy the parabolic wav
equation, such functions falling into three classes –
attenuation, current distribution, and reflection coefficien
functions. The application of their tabulated values fa
cilitates the computation of propagation around, radiatio
from, and reflection from convex surfaces. This wor
has already seen some applications in the fields
ground-space communication and missile antenna desig

Every radar engineer is familiar with the use of circula
polarization to discriminate against echoes from precip
tation. Mr. Huynen's work is, in a sense, an extension
the basic principle of this application — the varying rada
reflectivity of objects as a function of polarization –
which may ultimately add another dimension to the in
formation by radar systems. To lay the groundwork fo
potential application, a thorough study of this propert
is being conducted. Considering a particular target and a
possible circular, elliptical, and linear polarizations, ther
is one polarization which gives the maximum radar re
turn and two polarizations for which no return wha
ever is contained As Mr. Huynen points out, "These thre
parameters are means to the end of determining the com
plete radar target scattering matrix. Conventional mea
surements at horizontal and vertical polarizations do no
give sufficient information to predict the return for a
target orientations." Considerable progress has been mad
recently in identifying these characteristic maximum an
null polarizations experimentally and in making labora
tory studies of various basic shapes.

The atmosphere has many effects on radio transmissio
which must be considered in the design of any com
munication system. Extensive data have been tabulated o
such factors as attenuation, refraction, waveform disto

range and doppler frequency deviations, and polari-
on rotation. A continuing phase of this activity is
planning of experiments designed to learn more about
electrical properties of the atmosphere and their
t on ground-space communication. Radio astronomy
the observation of satellite transmissions have been
principal tools in these experiments.

s a result of considering the severe mechanical prob-
s encountered in the construction of a convention-
steerable large aperture parabolic antenna, such as
ld be used as a radio telescope, a program to investi-
the properties of a fixed spherical reflector with a
eable feed was started. Theoretical results encouraged
struction of a 5-foot diameter model which is being
ed at 37 gc. All indications are that this configuration
become a serious competitor of the large parabola.
king forward to the construction of a large radio tele-
pe of this type, mechanical engineers in the Micro-
e Applications Department are studying the structural
blems to be encountered.

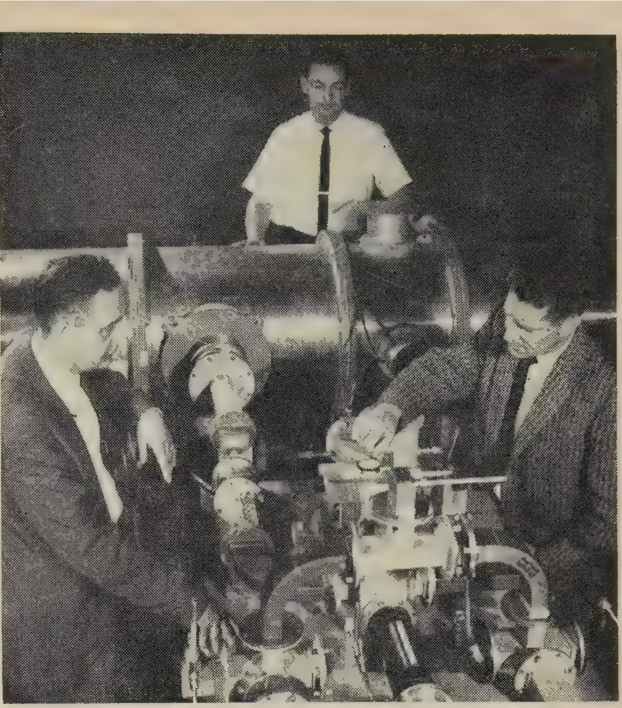
series of exploratory studies in low noise amplification
conducted as a part of the radio astronomy program,
aim being to increase the sensitivity of the projected
scope system. This began with maser research, but
ntly the emphasis has been on diode circuitry, such as
metric amplifiers; traveling wave parametric ampli-
; tunnel diode amplifiers, oscillators and converters;
harmonic generators. These devices obviously have
er usefulness than just in radio astronomy, and several
ications for the Satellite Systems project are being
idered.

elopment Activities

he contributions of the Microwave Applications De-
tment, A. R. Ellis, manager, to LMSD's missile and
llite projects are vital because the main purpose of
test flights being conducted is the gathering of data
ich must, of course, be relayed to the ground by
io links. Close coordination of missile design and r-f
em design occurs because Electromagnetics personnel
k with the structural designers from the earliest
ges of a project. According to A. F. Gaetano, head of
Electromagnetics Systems Section, "It is sometimes
ed that an antenna should be omnidirectional, have
db gain, be flush mounted, not protrude inward into
missile body, and have 100 pounds of lift. While
se requirements are impossible, the basic problems call
our close cooperation with the structure designers to
ive at satisfactory solutions."

This cooperation starts with a study of the require-
nts of the communication link — whether it be for a
nsponder beacon, data telemetry, command transmis-
n, or Azusa tracking — to determine the pattern cover-
which will be needed. This and the vehicle configura-
n set the type of antenna to be used, and construction
the laboratory model to be tested on a mockup of the
hicle begins. When this phase is successful, the Me-
anical Design Section group begins its work which will
d with the release of fully-authenticated drawings to
SD Manufacturing. Other parts of the design pro-
dure are the writing of acceptance test specifications
the end item, selection of suitable materials for the
plication, and stress analysis.

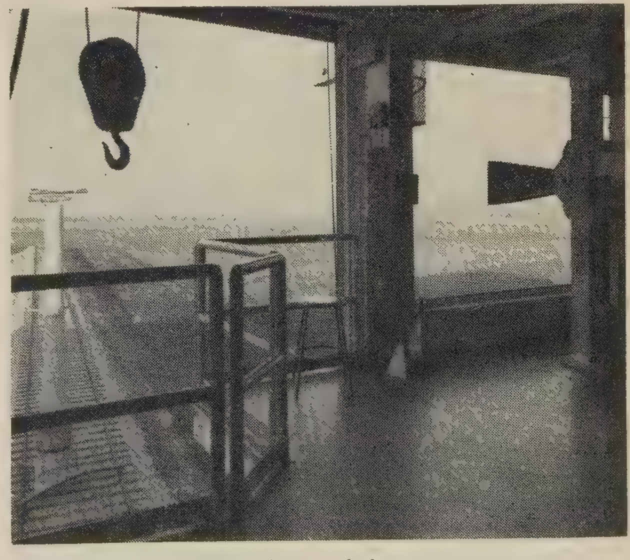
The antennas which this department provides for



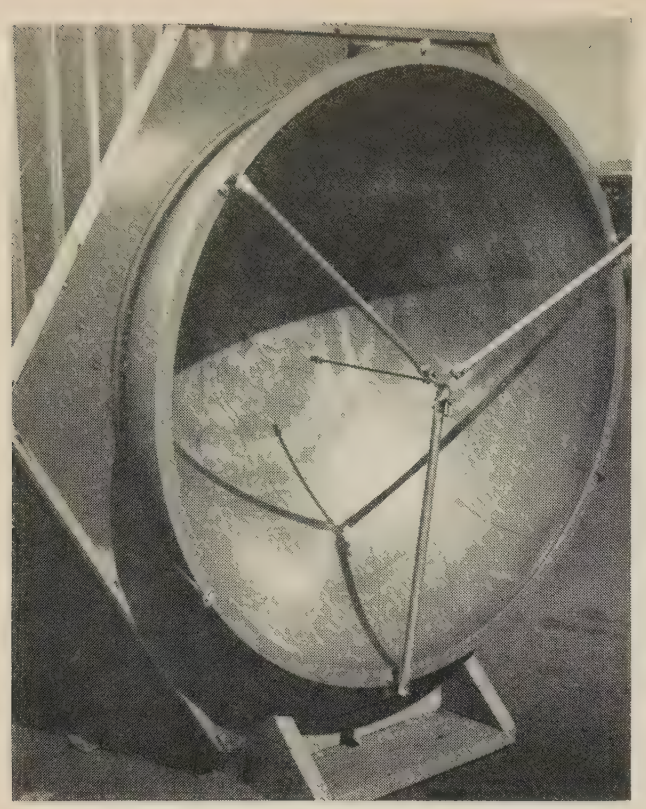
E. A. Blasi, left, and A. S. Dunbar examine the Hot Shot Tunnel mockup and associated instrumentation being assembled by Tom Meighan, rear.

Lockheed's missiles and space vehicles may be divided into four broad categories: exit, orbit, space and re-entry, with environment being the major criterion for this grouping. Flush-mounted antennas must be used for aerodynamic reasons during exit, and this limits the types which can be used. Typical examples are cavity-backed slots, open-ended waveguide radiators, and corrugation-or dielectric-loaded slow wave structures. Satisfactory designs exist for most application, but some design effort is being directed toward reducing antenna size.

Initially, simple antenna designs were satisfactory for use on orbiting vehicles, but applications are becoming



View from the balcony of one of the antenna pattern ranges. Conveniences include adjusting the model on the tower from the balcony, moving the tower out automatically, and making the measurements from the locations shown.



K_a band model of a proposed radio astronomy antenna being readied for test. Contours have been marked on the spherical reflector showing the deviations from the true contour with an accuracy of one-thousandth of an inch.

more demanding and more sophisticated. One example of a more advanced design is a data-link antenna which consists of 40 serrated wave guide radiators on the skin of the vehicle. The vertical pattern (in the plane of the satellite axis) is controlled by slot width and guide wavelength, while beam shaping in the horizontal plane is accomplished by using six elements at once in a broadside array. The array is scanned by the rotation of a capacity-coupled printed circuit switch. Looking a little further to the future, mechanically unfurled and "pressure-erected" structures are being considered for orbital and space flight applications. In fact, the Unfurlable Antenna Design contract sponsored by W.A.D.D. provides another example of the unique cooperation between research and development personnel.

The generalized needs of future space vehicles, the various problems to be encountered in the space environment, and the general concepts of antenna unfurling (which means unfolding or erecting a large structure from a small package in which it has been packed for the launch phase) were studied by research personnel. With general guidelines set forth, development people were called in to incorporate these ideas in a series of feasibility and demonstration models. For example, a log periodic antenna has been fabricated of aluminum foil tubing. When deflated, the entire antenna can be rolled into a package about the size of a man's fist, and when inflated to several pounds per square inch pressure, the tubing unrolls itself to become a structure possessing sufficient strength to stand by itself when the pressure is removed. This is an important consideration because any antenna inflated in space will soon become punctured by micrometeori and its survival will depend on an ability to remain ri after the internal pressure is lost.

Antenna design for re-entry vehicles presents ma problems because of the high temperature environme structural problems, and difficult pattern coverage quirements. Such materials as sintered alumina and be lium oxide for windows and stainless steel for the me parts must be used because of the high temperatu encountered. In spite of these difficulties, a number designs is being produced for the current series of Pola test flights.

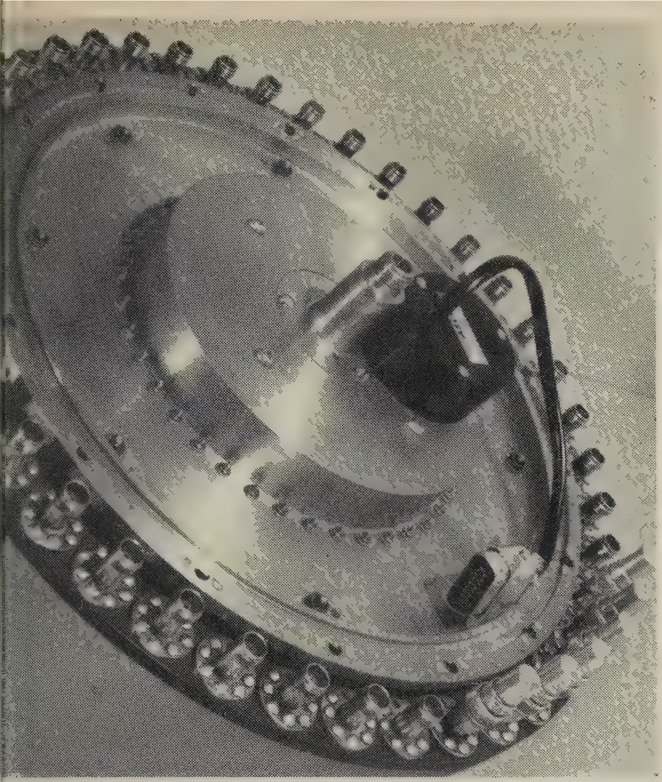
History

The Lockheed Missiles and Space Division was ganized January 2, 1954, beginning with a handful employees operating in a small corner of one of the co poration's buildings in Van Nuys, and has grown stead ever since. Today more than 20,000 people, working nearly three million square feet of plant space, are bri ing their two major projects to operational readiness ye before the targeted deadline.

The division has developed, as an organizational tity, one of the largest and finest industrial research cilities in the country. Its R & D staff of over 2,0 would do justice to any of the world's leading universit Basic research activities cover almost every field of scien including nuclear physics, ultrasonics, high altitude search, magneto-hydrodynamics, new and rare materi space vehicles and systems, planetary atmospheres, dynamics, human engineering, advanced electronics a many others.

But to go back to the beginning, early in 1954, t group that was destined to become the Electromagnet Division set up shop in the Northeast corner of Buildi 902 in Van Nuys, Mr. Blasi being the first man in t group. At that time, a nucleus of engineers from Lo heed's California Division were designing the X-7A, test bed for ram-jet engines, and the X-7B, a test bed f radar target seekers. Besides providing beacon, teleme and command antennas for these missiles, one of the fi jobs of the Electromagnetics group was the design of t antenna and radar augmentation system for the XQ target drone, this project seeing the earliest application a Luneberg lens for radar target augmentation. Anoth pioneering project was the design of the first anten built to withstand re-entry conditions — the telemet antenna of the X-17 re-entry test vehicle.

When the Electromagnetics staff had grown to a proximately 35 in 1956, it became apparent that sp cialized facilities were needed, and plans were made f construction in Van Nuys. However, these plans we never carried out as the tremendous activity that wou be required to develop the Polaris Missile System and t Discoverer, Samos and Midas Satellite Systems was b coming apparent and was forcing the move of LMSD the San Francisco Bay area. However, planning of t present building began in 1956 as the result of disc sions between Mr. Blasi and the late Dr. Louis Ridenour, then Director of Research of LMSD. Aft working in various temporary quarters in the Palo Al and Sunnyvale plants for about six months while t "Antenna Building" was under construction, departme



ty position microwave switch with amplitude and phase trol for simultaneously feeding the selected six elements of orty element array. This is part of the data-link antenna em.

sonnel numbering about 50, moved into what is now laboratory area of the present building in October 57. An additional 10,000 square feet of office space s constructed in 1958 to bring the building essentially its present form.

cilities

The present facility might be described in terms of a ook's Tour" through it. After going through the office the laboratory area, one might walk through the im- lance lab, with equipment for measurements from 10 40,000 mc; past the small but well-equipped machine op where experimental models are built; past the high itude test chamber area; and then up to the third floor ttern range instrument room. Here one notes a unique d convenient method of operation — it is only a few ps from the recorder console to a balcony from which technician mounts his model on the tower. At the o of a switch, the motorized tower moves, on tracks, desired distance away from the building and mea- rements begin. Two such ranges are used for antenna ttern measurements and two at the opposite end of the ilding are used for reflectivity measurements.

In walking back through the laboratory area, one might serve reflectivity measurements being made in the foot x 20 foot x 67 foot anechoic chamber; look in on ser; parametric amplifier, and tunnel diode circuit de- lopment going on in the microwave circuit lab; see a electric sample being tested at a temperature of several ousand degrees, and then watch the recording of a ellite transmission in the Space Observatory, which is uipped with signal strength recorders and receivers ned to all current satellite transmitter frequencies.

While the laboratory has been one of the most advanced antenna and microwave facilities in the industry for several years, new and improved equipment is constantly being added — the vacuum chamber for antenna breakdown testing, the satellite-tracking radio interferometer, and the high temperature dielectrometer being recent items. An important phase of the interplay between research and development is the continual joint use of all equipment by personnel in each area.

Personnel

The personnel of the Electromagnetics Division numbers about 105, with about 55 per cent being professional people holding bachelor's or advanced degrees. In fact, 12 have received master's degrees in electrical engineering or physics and three have received doctoral degrees in electrical engineering. However, having adequate technician support for the professional engineers is emphasized; in the electrical development section, for example, there is at least one technician for each of the 14 engineers. Continuing education is stressed: Lockheed's Graduate Study program is well represented in the Division by five young men who work three-quarters time at the laboratory while pursuing graduate degrees at company expense at nearby Stanford University and a number of others take courses occasionally at Stanford, University of California or San Jose State College.

As far as LMSD is concerned, the lowest level of supervisor consists of Section Heads: J. S. LaRue, Electromagnetic Physics and P. D. Kennedy, Theoretical Analysis in Electromagnetics Research; and A. F. Gaetano, Electromagnetic Systems and C. J. Oliver, Mechanical Design in Microwave Applications, but a number of junior men are receiving management training in their function as "Technical Leaders". The Technical Leader is responsible for a project or group of related projects and the group of three to ten men working on it. He is expected to plan the work, be concerned with budget considerations, guide the performance of the other workers on the project, and follow through on the accomplishment of the project objectives.

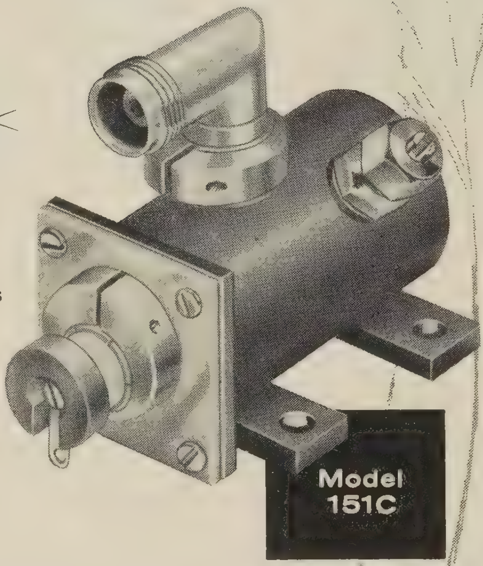
Conclusion

The Electromagnetics Division is literally a million dollar business, and this is true even without including the end-item manufacture which is done by other LMSD departments. Electromagnetics Research is currently performing on four contracts sponsored by various governmental agencies, six major company-sponsored general and applied research projects, and six major studies in support of the Polaris and Satellite System projects. The end result of this work is essentially many reports, of varying degrees of formality and a great deal of day-to-day consultation with Polaris and Satellite System personnel. Microwave Applications turns out approximately 40 complete designs for antennas and r-f components per year, assists with several major research projects — notably the radio telescope and unfurlable antenna studies, and carries on several exploratory studies of mechanical and electrical devices. It is certain that Electromagnetics will continue its contributions to LMSD's overall-program — pure and applied research in all phases of electromagnetic science and design of all r-f components and antennas for Lockheed missiles and space vehicles.

MINIATURE
"C" BAND
TRIODE
OSCILLATOR

GOMBOS

4½ ounces



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±10 KC per degree C
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Only 200V plate voltage

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We are a recognized, quality manufacturer of a complete line of Triode Oscillators, Amplifiers and Multipliers from "L" Band through "C" Band. We also produce a complete line of Tunable Band Pass Filters from "L" through "Ku" Band.

WRITE TODAY for Data Sheet C-2.

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New Products

(*Continued from page 102*)

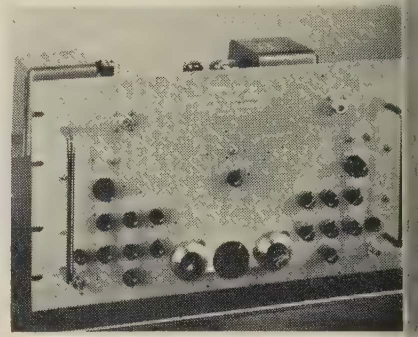
high power rating, over-all stabili superior specifications and convenient line arrangements make the units perior to coupler type units as calibrati standards.

These units can operate over la ranges of temperature and humidity a are available in 10 db and 20 db valu for L through E bands. Priced from $ to $450, they are available from stoc

Circle Reader Service Card 96

—*mwj*—

BEACON CODE SIMULATOR AVAILABLE



Micro-Tel Corp., Baltimore, Md., nounces the availability of model PS 10A Beacon Code Simulator. The inst ment is a double-pulsed microwave sig source covering 2.7-2.9 kmc and 5.1- kmc. Pulse width can be adjusted fr 0.3-10 μsec., pulse spacing from 0-1 μsec., and prf from 10-2000 pps.

An additional feature is that paral sets of pulse controls can be used pre-set all pulse parameters in eit "C" or "S" band. One-hundred mi watts of pulse or cw power is availa in both bands through 40-db variable tenuators for sensitivity measuremen The entire instrument is housed in 19 inch x 10 1/2 inch x 15 inch cabi and will operate from 60 to 400 power sources.

Primary purpose of the instrument to check sensitivity and pulse decodi circuitry of radar beacons.

Circle Reader Service Card 97

—*mwj*—

NEW HIGH VOLTAGE PULSE TUBE ANNOUNCED

The Central Electronics Manufactur Division, Denville, N.J., of the Nucle Corporation of America announces new forced-air-cooled triode, the XD Specifically designed for pulse operati the XD-5 will switch 30 amperes 40,000 volts with a duty of .030. T results in a peak power output of megawatts.

The XD-5 is available for immedi delivery. Complete technical data available from the manufacturer.

Circle Reader Service Card 98

—*mwj*—

VARIAN REPORTS SALES AND RNINGS INCREASE AND RECORD BACKLOG

A sales increase of 23 per cent, earn- s rise of 18 per cent, and an all-time ord backlog of $27,590,999 are re- ted by Varian Associates, Palo Alto, ., for the first three quarters of the 60 fiscal year, according to H. Myrl arns, president.

Sales for the first 39 weeks of Varian's al year were $34,038,525, up from 7,756,201 for the comparable period year ago. Net income for the period led July 2, 1960 was $2,116,455 or 67c share which compares with $1,788,- 3 or 57c per share for the same period 1959. Order receipts of $16,327,217 ring the third quarter period brought backlog to the record $27,590,999.

Since the close of the third quarter rian has completed the sale of 210,230 ares of its capital stock offered to its areholders through subscription rights. t proceeds of the offering after de- ction of expenses are expected to be proximately $8,925,000.

Current bank loans of $2,500,000 have en retired with a part of the proceeds. ve million dollars has been invested nding utilization for Varian's current nt expansion program. The remainder the proceeds is being held as cash to et immediate capital requirements, ac- rding to Stearns.

Included in the building program ich is already underway are a 65,000 uare foot administration building, a 0,000 square foot manufacturing build- g for the Radiation Division and the acuum Products Division, a 15,000 uare foot cafeteria and additions of ,400 square feet to the Tube Division anufacturing and processing buildings.

—*mwj*—

EWLETT-PACKARD TO INCREASE NUMBER OF SHARES

The shareholders of Hewlett-Packard, lo Alto, Cal., voted Aug. 19, 1960 to crease the number of shares the com- ny is authorized to issue from 5,000,- 0 to 15,000,000 shares.

This action makes possible a three- r-one stock split, to be accomplished by 200 per cent stock dividend, which had en proposed by the company's Board Directors July 19.

Company officials announced that ap- ication will be made to the California ommissioner of Corporations for au- orization to pay the dividend on Sep- mber 15, 1960, to all shareholders of cord September 1, 1960.

The stock dividend, according to Pres- ent David Packard, will not change e equity of shareholders. It will, how- er, increase the total number of shares circulation and make possible a wider se of stock ownership.

"This wider base of ownership would lp qualify Hewlett-Packard stock for listing on the New York Stock Exchange," he said. "Decision to apply for listing, however, will be deferred until the company's Board of Directors has had an opportunity to review the current fiscal year's operation ending October 31, 1960."

—*mwj*—

LFE TO VOTE ON STOCK INCREASE

Stockholders of Laboratory For Electronics, Inc., Boston, Mass., will vote on a proposed charter amendment to increase the number of shares of authorized common stock, par value $1 per share, from 750,000 to 1,250,000 at LFE's Annual Meeting, September 13.

LFE is asking for the 500,000 share increase to ". . . provide the Board of Directors with the flexibility necessary to take advantage of opportunities for acquisition requiring prompt and decisive action," according to Henry W. Harding, LFE president.

"The management is investigating a number of possible acquisitions with a view to strengthening and diversifying the corporation's business," Mr. Harding stated, "but no agreements have yet been reached and it is not possible to predict whether or not any current investigations will produce definite results."

Other business scheduled to come before the meeting includes election of the Board to serve for the next year. No change in the Board is anticipated.

—*mwj*—

INDIANA GENERAL CORP. LISTED ON NEW YORK STOCK EXCHANGE

Indiana General Corp., Valparaiso, Ind., one of the world's largest producers of magnetic materials, was listed on August 23, 1960 on the New York Stock Exchange. The Company is known on the Exchange trading floor by the symbol IGC.

Robert F. Smith, president, John H. Bouwmeester, executive vice-president, and Anthony J. Astrologes, vice-president, treasurer and secretary, all of whom are directors, represented the Company in a listing ceremony at the start of the day's trading.

Mr. Smith announced that a total of 1,215,522 shares of Indiana General stock is being listed. He also stated that the company looks forward to a broader market and more interest in its securities as a result of the N.Y.S.E. listing.

For the six months ending June 30, 1960, consolidated net sales were $10,410,082, with net income after taxes of $733,313, or 65c per share; as compared with sales of $9,772,311 and net income of $795,243, or 71c per share, for the like period of 1959.

Indiana General, which has been listed

(*Continued on page 110*)

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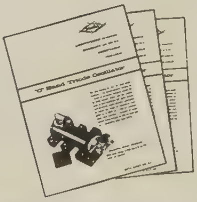

JOHN
GOMBOS
CO., INC.

WEBRO ROAD, CLIFTON, N. J.

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Financial News

(*Continued from page 109*)

on the Midwest Stock Exchange since 1937, has approximately 2,700 shareholders. The company split its common stock on a two-for-one basis in February, 1955, and May, 1960.

Indiana General Corp., with executive offices in Valparaiso, Indiana, was formed November 16, 1959, when General Ceramics Corp. (founded in 1906) was merged into The Indiana Steel Products Co., established in 1908.

The company is engaged in the research, development, and production of permanent magnets and ferrite materials, and a range of products utilizing these materials for electronic, materials handling, and magnetic separation applications.

Indiana General has sales offices in 47 cities, and approximately 1500 employees in the following divisions and subsidiary company: Indiana Steel Products division, Valparaiso, Indiana; General Ceramics division, Keasbey, New Jersey; Stearns Magnetic Products division, Milwaukee, Wisconsin; and The Indiana Steel Products Co. of Canada Limited, Kitchener, Ontario.

—mwj—

SCIENTIFIC-ATLANTA REPORTS SALES AND PROFIT GAINS

With a sales increase of 38 per cent and net profit increase of 47 per cent, Scientific-Atlanta, Inc., Atlanta, Ga. has reported record volume and profit results for the fiscal year ended June 30, 1960. Glen P. Robinson, Jr., President of the electronics firm, reported net sales for the year of $1,970,879 and net profit of $105,018, compared with sales of $1,430,853 and profit of $71,447 for the previous year. Net profit for the year was equal to 47c a share compared with 35c a share last year.

The President reported that the company completed the year in a strengthened financial position. The increase in sales was accomplished with only minor expansions in facilities and staff. The successful year enabled the company to make a contribution of $19,982 to the Employees Profit Sharing Plan, compared with $15,895 for the previous year.

Scientific-Atlanta manufactures antenna and microwave test instruments used in the design and production of communications, radar, and missile guidance equipment. Virtually all of the company's sales are of instruments designed and produced by its own staff of 117 employees, of whom 25 are graduate engineers.

Scientific-Atlanta presently has over 500 stockholders, compared with approximately 200 a year ago. The company's stock is traded over-the-counter in
lanta and several other major cities.

—mwj—

FXR, INC. SALES, INCOME REGISTER RECORD HIGHS IN FIRST HALF

Sales of FXR, Inc., Woodside, N.
manufacturer of microwave test inst
ments and associated equipment,
creased 43 per cent to a record high
$3,822,200 in the six months enc
July 3, 1960, compared to $2,667,008
the similar 1959 period. Net inco
rose to $274,721, also a record, co
pared to $163,513 for the 1959 first-h
according to Henry Feldmann, presid
and chairman of the company.

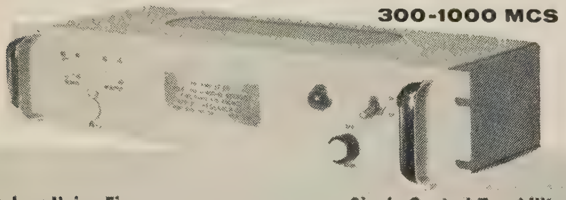
The current year's six-month earni
were the equivalent of 61c a share,
449,567 common shares outstanding. I
the 1959 first-half, per share earni
were 38c on 433,000 shares.

"Our first-half results were achie
at a time when so many businesses h
been experiencing disappointing pro
and dull sales," Mr. Feldmann said. "
me this is proof of the vitality of
microwave industry and of FXR's stro
position within it. In anticipation
yet further development, we are c
rently engaged in a major building
pansion and expect second-half sales
reflect the increase in production ca
city at our disposal."

—mwj—

tunable RF AMPLIFIER

300-1000 MCS



- Low Noise Figure
- Tuning Range to 150 mcs
- 10 mcs Bandwidth
- Single Control Tunability
- High Gain
- High Reliability

This versatile and dependable UHF RF amplifier permits the user to vary the frequency of the amplifier up to ±10% of nominal center frequency (not to exceed 150 mcs range) in the frequency range of 300 - 1000 mcs. Tuning is done by means of a slotted shaft accessible through the front panel.

The amplifier is supplied complete with power supply, mounted on a 3½" high panel to fit a standard rack.

GENERAL SPECIFICATIONS — MODEL UH-2 (AT)

Center Frequency	300 mcs to 1000 mcs
Freq. Range (tunable)	Up to ±10% of nominal F° (not to exceed 150 mcs range)
Bandwidth	10 mcs nominal
Gain	5.5 db at 400 mcs; 9.0 db at 1000 mcs
Noise Figure	18 db nominal (representative values)
Source and Output Impedance	50 ohms

Write for further information.

Applied Research inc.

76 South Bayles Avenue
Port Washington, N. Y.

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THE FINEST QUALITY BRASS AND ALUMINUM STANDARD WAVEGUIDE FLANGES in stock at Formcraft—all precision made to military standards. For rigid and flexible waveguides.

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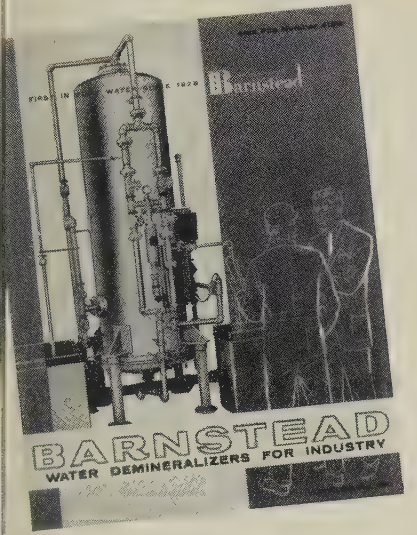

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SINCE 1878

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Letters

To the Editor

"the microwave journal"
Brookline 46, Massachusetts

Att. Mr. Theodore S. Saad

Dear Ted:

I would like to say that Bruno Weinschel's "Accuracy in R-F Measurements" in the June, 1960 issue is a very fine article.

This article brings to mind some extremely valuable calibration services that the National Bureau of Standards has recently performed. NBS has measured the effective efficiency of two bolometer mounts that were designed by Narda for the General Electric Company.

The certificate issued by NBS indicates that one mount has an effective efficiency of 98.3 per cent at 9 kmc and that the other mount had an efficiency of 97.2 per cent. They have also indicated that these values are accurate to ±1 per cent. "The measurements were performed under ambient conditions of approximately 23°C and 50 per cent relative humidity. The temperature of the bolometer mount was maintained constant to 0.01°C during the calibration. The bolometer was operated at 200 ohms, the VSWR of the power source was less than 1.02, and the frequency was accurate to 0.02 per cent The calibration was made at a nominal power level of 10 milliwatts."

This points out, I think, the service that the Bureau of Standards provides since information of this type would be extremely difficult to obtain in the general laboratory.

Sincerely yours,

Leonard I. Kent
Director of Engineering
The Narda Microwave Corp.

—mwj—

Mr. G. J. Wheeler

"the microwave journal"
Brookline 46, Massachusetts

Dear Mr. Wheeler:

We have read your editorial "The Ferrite Market" in the August *microwave journal* with particular interest. We have been intensely engaged in research and development on ferroelectrics for low-frequency applications, especially piezoelectricity, with an occasional excursion into the ferrite field.

Your article implies that microwave application of ferroelectrics may offer us a nice extra pasture close to our own back yard. Unfortunately our experience so far does not bear this out. We have had microwave engineers from several organizations rush in asking for a variety of samples on high priority, but

(*Continued on page 112*)

Presenting Another
New Development
from
Lindsay Research

Ultra High Purity
YTTRIUM
OXIDE
(Codes 1117 and 1118)

Until recently, the best Yttrium Oxide commercially available has been *Lindsay* Yttrium Oxide Code 1116, designated as 99.99% purity. Continuing progress in rare earth separation technology now makes it possible to produce even higher purity materials.

These new materials are *Lindsay* Yttrium Oxide Codes 1117 and 1118.

The largest single application for Yttrium Oxide today is in YIGs for microwave use. Although *Lindsay* Codes 1115 and 1116 are suitable for most polycrystalline applications, the new codes 1117 or 1118 may offer performance improvement, particularly in single crystal YIGs.

The new code 1117 and 1118 materials are "spectrographically pure" and better insofar as rare earth impurities are concerned.

Availability is presently limited to experimental quantities, but production can be increased with adequate lead-time.

Some suggested uses are: electronic ceramic materials, source of high purity yttrium for semiconductor and thermoelectric devices. Your own experimental research may disclose other significant and valuable applications.

Technical data on codes 1117 and 1118 will be found in *Lindsay's* Technical Data Sheet on "Ultra High Purity Yttrium Salts." It is available to you promptly on letterhead request.

TRONA™

LINDSAY CHEMICAL DIVISION
American Potash &
Chemical Corporation
99 Park Avenue, New York 16, N.Y.
•
3000 West Sixth St., Los Angeles 54, Calif.

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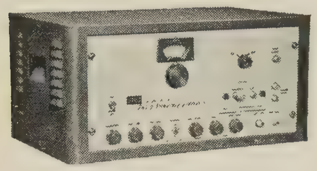
JERROLD

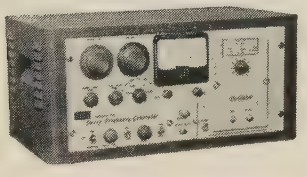
R. F. Test Equipment

Quantitative Measurements Using Sweep Frequency Techniques



Model 900A—THE MOST VERSATILE SWEEP GENERATOR $1,260.00

CENTER FREQUENCY—VHF 0.5 to 400 MC UHF 275 to 1000 MCS—SWEEP WIDTH—up to 400 MCS—FLATNESS—±0.5 db over widest sweep!

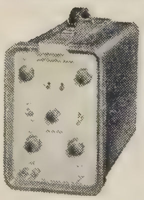


Model 707—ULTRA FLAT SWEEP GENERATOR $795.00

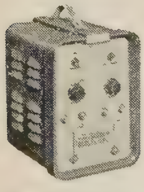
Featuring ±5/100 db flatness—Plug-in osc. heads*; variable sweep rates from 1/min. to 60/sec.; all electronic sweep fundamental frequencies; sweep width min. of 1% to 120% of C.F.

*Heads available within the spectrum 2 to 265 MCS

Models 601/602—PORTABLE GENERAL PURPOSE $295.00

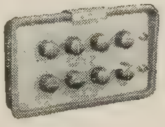


COVERAGE—Model 601—12 to 220 MCS. Model 602—4 to 112 MCS—FLATNESS — ±0.5 db OUTPUT—up to 2.5 V RMS WIDTH-1% to 120% of C.F.



Model FD-30 $250.00

High speed DPDT coaxial switch permitting oscilloscope measurements without calibration—all measurements referenced continuously against standard attenuators.



Model AV-50 Variable Precision Attenuator $150.00

Long life rotary switches; dual wiping silver contacts on "Kel-F" dielectric. 0-62.5 db in ½ db steps; DC to 500 MCS.

Write for catalog and technical Newsletter series on measurements using sweep frequency techniques. Prices and data subject to change without notice.

JERROLD ELECTRONICS CORPORATION
Industrial Products Division Dept. ITE-48
The Jerrold Building, Philadelphia 32, Pa.
Jerrold Electronics (Canada) Ltd., Toronto
Export Representative: Rocke International, N.Y. 16, N.Y.

Letters to the Editor

(*Continued from page 111*)

nothing happened after these were delivered.

The situation is somewhat reminiscent of the excitement about ferroelectric memory cells some five years ago. A great deal of effort was spent but somehow ferroelectrics could not catch up with ferrite cores in versatility and reliability. Will we fare better in the microwave field?

Sincerely yours,

Hans Jaffe
Director of Electronic Research
Clevite Corporation

—*mwj*—

Hans Jaffe
Clevite Corporation
Cleveland 8, Ohio

Dear Mr. Jaffe:

Thank you for your interest in my editorial. You raise the question whether the flurry in ferroelectric activity at microwaves will amount to anything or whether it will die a natural death as many other research activities have. Although my knowledge of what's going
is limited, I believe that the future
microwave ferroelectrics is bright.

At Sylvania in Mountain View, Ca
fornia (where I am employed, when
writing for *the microwave journal*), th
is a small, but active, group trying
develop new devices using these
terials. I know some of the engine
who rushed in to you asking for sampl
The results look promising, but as y
probably appreciate, engineers don't l
to discuss their results until they f
they have a real accomplishment.

Some of the devices which app
feasible are worth mentioning. I dou
if all will prove practicable, but I
sure some will be in production with
a year. These include a solid state, t
able local oscillator, a voltage-contr
lable phase shifter, various types of
crowave switches, and many other
vices.

Basically, the biggest problem now
losses in the material at microwave f
quencies. When this is licked, the
tential should be unlimited.

Yours truly,
Gershon J. Whee

Industry News

(*Continued from page 84*)

RIBLET APPOINTED TO PROFESSORSHIP AT HARVARD

Dean Harvey Brooks announces the appointment of Henry J. Riblet, Boston electronics executive, as professor of engineering practice in Harvard University, Cambridge, Mass.

Dr. Riblet, an expert in microwave engineering, is president of Microwave Development Laboratories, Inc. He is widely known for his work in the theory and design of microwave antennas and radio frequency components. Earlier, Dr. Riblet was an engineer for Submarine Signal Co., and a research associate at M.I.T. He has taught mathematics at Yale, Adelphi and Hofstra College.

—*mwj*—

1960 NEREM MEETING

"Electronics . . . Pulse of Progress" will be the theme of the Northeast Electronics Research and Engineering Meeting, to be held November 15, 16 and 17, 1960, at the Commonwealth Armory and the Sheraton-Plaza Hotel, Boston, Mass. The annual meeting is sponsored by the Boston, Connecticut and Western Massachusetts sections of the IRE, and, according to Arthur Winston, 1960 NEREM Chairman, has become the third largest such meeting in the nation.

The technical sessions program, under the direction of James H. Mulligan, Jr., of New York University, is comprised
forty unclassified and two classified s
sions. Research papers will be deliver
at the Sheraton-Plaza, and applicatic
papers at the Armory. The two classifi
sessions, sponsored by the Bureau
Naval Warfare, are concerned with AS
They will be held at Murray Hall, Bost
Naval Station, on Wednesday morni
and afternoon, November 16.

Commonwealth Armory will be the s
of 375 exhibit units. Stewart Gibs
Exhibits Manager, says that due to t
growth of national interest in NERE
it was necessary to limit exhibitors to
two unit space allocation.

Registration fees will be $2.00 for I
members, $4.00 for non-members. Reg
trants will be provided, at no cha
with a 200-page illustrated digest of t
technical program, as well as an
hibitors directory and guide.

—*mwj*—

MICROWAVE ASSOCIATES AWARDED NAVY CONTRACT FC RADAR RESEARCH

Microwave Associates, Inc., Burlir
ton, Mass., announces the award of
Navy contract for $91,000.00 coveri
research and development of electro
techniques related to improvement
radar electronic scanning capabilities.

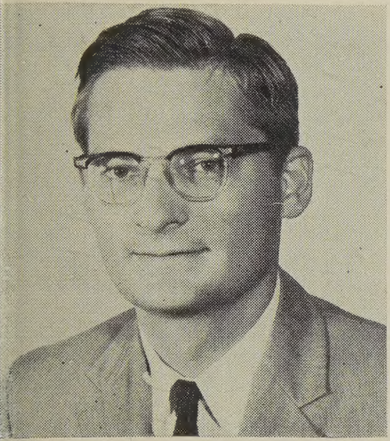
The company will conduct a survey
phase-shifting techniques that sh
promise of advancing the electrical sc

g art and will also develop and supply the Navy several models of a phase-ter employing the techniques re-rched under the first phase of the con-t.

Iicrowave Associates has been active he development of gaseous and solid-e switching devices for use in latest e-of-the-art radars. It is hoped that cessful culmination of this program l facilitate the use of phased-array hniques in new radars.

—*mwj*—

JOHN F. MOORE APPOINTED MANAGER AT LOCKHEED



ohn F. Moore has been appointed nager of the Product Development partment, Information Technology Di-ion, of Lockheed Electronics Co., ainfield, N.J. He will be responsible the creation of new products in tele-try, closed-circuit TV, and other lines, h as medical electronics.

Moore holds a BS degree in physics m the Massachusetts Institute of Tech-logy and an MS degree in applied phy-s from Harvard University. He was a low of the National Science Founda-n in 1952-53.

Previous to joining Lockheed Elec-nics, Moore was employed as Direc-r of Research and Engineering at the COP Division of Electro-Mechanical search in its Princeton, N.J., offices. ior to this, he was engaged in design microwave and tropospheric scatter stems as Communications Group Leader r Hycon Eastern, Inc., Cambridge, ass.

Earlier in his career, Moore was em-oyed by the Raytheon Manufacturing ., Waltham, Mass., and Woburn En-neering Co., Woburn, Mass.

Moore has nine patent disclosures to s credit and has had articles concerned th microwave devices and bandwidth duction published in several technical urnals.

—*mwj*—

NTENNA SYSTEMS, INC. OPENS ENGINEERING LABORATORY

Antenna Systems, Inc., Hingham, ass., has announced the opening of a w engineering laboratory adjacent to their manufacturing facility in the Hingham Industrial Center. This building of 3500 sq. feet, contains modern laboratory facilities for the design and development of antennas and RF components, as well as engineering offices, conference rooms and drafting room. Part of this new laboratory are outside pattern ranges, equipped with automatic pattern recording instruments and a remote-controlled pedestal for the testing of antennas and RF components.

The engineering laboratory will centralize all engineering activity including mechanical structural and electrical design.

—*mwj*—

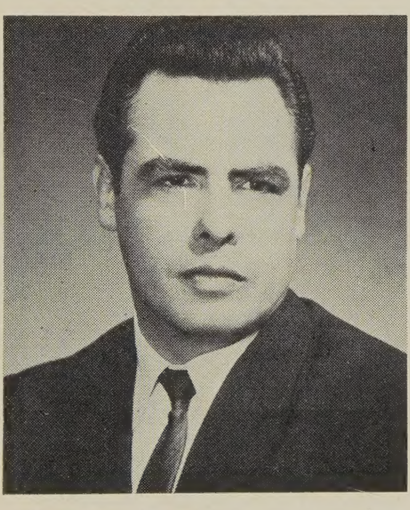
KOAT-TV BUYS ADLER MICROWAVE SYSTEM

A five-hop microwave system has been purchased from Adler Electronics, New Rochelle, N.Y. by KOAT-TV, Albuquerque, N.M. Scheduled for October completion, the 2 kmc heterodyne repeater system will provide KOAT-TV with ABC network programs picked up off-the-air from KTVK in Phoenix.

The complete turnkey installation, including relay equipment, towers, antennas, shelters, auxiliary power, and VHF communications is being supplied by the Adler Industrial Products Division.

—*mwj*—

ENGINEER JOINS FXR WEST COAST STAFF

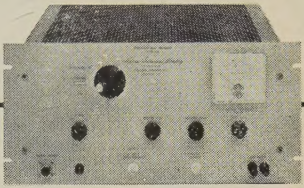


James O. Haning, a design engineer and former college instructor, has joined the West Coast sales staff of FXR, Inc., Woodside, N.Y., manufacturer of microwave and electronic equipment. He will cover the San Francisco area from offices at Palo Alto under the overall direction of the regional FXR office at Venice, Calif.

Haning was previously with Admiral Corp. and Lockheed Aircraft Corp. working on aircraft and missile equipment. He taught engineering and electronics at Pennsylvania State University and at the University of Miami (Fla.).

—*mwj*—

for Accuracy in Precision Test Receivers



THE AIL TYPE 132

This high precision instrument combines a high gain, low noise figure, intermediate frequency receiver with a secondary standard of attenuation to deliver extremely accurate measurements in a variety of applications:

- Convenient and accurate method for the measurement of **NOISE FIGURE.**
- Ideally suited to high accuracy, quick laboratory **calibration of rf attenuators** at all frequencies.
- Rapid and accurate in measurement of the **selectivity characteristics** of rf filters, preselectors and similar devices.
- Valuable for measurement of **coupling factors** and directivities.

The Type 132 is designed to operate from the i-f output of a wide variety of standard microwave mixers. In combination with these and a suitable local oscillator it becomes a sensitive detector of microwave energy.

Write for descriptive literature.

AIRBORNE INSTRUMENTS LABORATORY
DEER PARK, LONG ISLAND, NEW YORK
A DIVISION OF CUTLER-HAMMER, INC.

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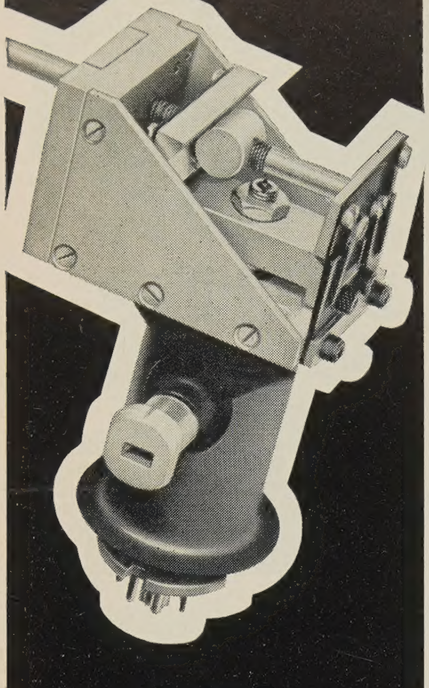

E.M.I.
Q-BAND REFLEX KLYSTRONS

Five high voltage, integral cavity types, with improved plate tuner for good frequency stability and freedom from microphony.

Type No.	Approx. f range KMc/s	Min. Power (mW)	I_A (mA) (at V_A=2KV)
R9521	35–40	15	12
R5146	34.2–35.6	30	10
R9546	32–38	15	12
R9518	28–32	15	12
R9547	24–28	15	12

Average electronic tuning range of above, 60 Mc/s; WG22 waveguide termination.

...AND A NEW K-BAND KLYSTRON:

with similar external dimensions and tuner to R9546:
R9602 22–26 15
Average electronic tuning range, 40 Mc/s; WG20 waveguide termination.
The extensive range of EMI special tubes includes: plug-in klystrons & cavities, photomultipliers, camera & C.R. tubes.

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804 NEWBRIDGE AVE. WESTBURY. L.I., N.Y. Tel: EDgewood 3-6650

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NEW LITERATURE

NEW 12-PAGE MICROWAVE PRESSURE WINDOW BROCHURE AVAILABLE

A new 12-page brochure describing waveguide pressure windows, their applications, and installation suggestions, is available from Microwave Associates, Inc., Burlington, Mass.

Microwave Associates' pressure windows are available as standard units to operate in the frequency range from 2.4 to 40 kmc and are designed to serve increasing power handling requirements over exceptionally wide temperature ranges.

The waveguide pressure windows freely propagate RF energy over a specific bandwidth of frequencies and seal off sections of waveguide in radar or other microwave waveguide applications where pressure, humidity, and dust seals are required.

The window types covered by the brochure are flange-mounted glass-kovar; flange-mounted mica; pressure window-waveguide assemblies; and solderable windows (including the new flexframe construction) for sealing reference cavities, filters, etc.

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—mwj—

HEWLETT-PACKARD PREPARES MONITORING BROCHURE

An 11-page application note describing latest techniques for the continuous monitoring of radar noise figures is now available from Hewlett-Packard Company, Palo Alto, Cal.

The application note, No. 43, reviews the theory of automatic noise figure measurements and outlines radar system requirements for integral noise figure meters. It also describes Hewlett-Packard's new noise figure meter (model 344A) and its various applications in operating radar sets.

Several illustrations are provided in the application note, including a block diagram of a typical radar system with an integral noise figure meter.

Copies of the application note, "Continuous Monitoring of Radar Noise Figures," may be obtained on request.

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—mwj—

FOAMFLEX CATALOG ISSUED

Complete technical data on the Foamflex series of coaxial connectors manufactured by Kings Electronics Co., Inc., Tuckahoe, N.Y., are contained in a new eight-page catalog just issued. These connectors are designed for use with Phelps Dodge Copper Products Corp.'s Foamflex Cable.

Also featured in this two-color bulletin are connectors which are specifically designed for applications involving Phelps Dodge's Spirafil and Styrof Cables.

A copy of the Foamflex catalog m be secured on request.

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—mwj—

NEW LITERATURE AVAILABLE FROM TRAK ELECTRONICS

"Designing for Stability," a two p technical article, is available from Tı Electronics Co. as Increductor No No. 6 and No. 7.

"Designing for Stability" was writ to assist design engineers in the use electrically controllable inductors applications in which the effects of te perature change and hysteresis must minimized.

Part 1 of this article describes t effects of hysteresis and temperatu changes and various open loop meth for minimizing these effects. The pr ciples and general considerations closed loop, bellweather stabilization also discussed.

Part 2 deals with specific closed lo and bellweather stabilization circuits.

Copies of "Designing for Stability" available at no cost on request.

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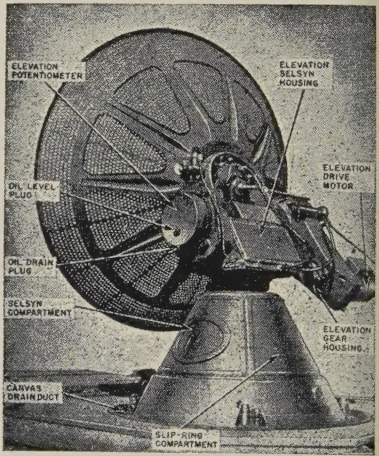
—mwj—

(*Continued on page 116*)



ANTENNA PEDESTAL
SCR 584—MP 61B

Full azimuth and elevation sweeps. 360 degree in azimuth. 210 degrees in elevation. Accurat to 1 mil. or better over system. Complete for ful tracking response. Angle acceleration rate: AZ. degrees per second squared EL.4 degrees per secon squared. Angle slewing rate: AZ 20 degrees pe sec. EL. 10 degrees per sec. Angle tracking rate 10 degrees per sec. Includes pedestal drives, selsyns potentiometers, drive motors, control amplidynes Excellent condition. Quantity in stock for im mediate shipment. Ideal for missile & satellit tracking, antenna pattern ranges, radar systems radio astronomy, any project requiring accurat response in elevation and azimuth.
Complete description in McGraw-Hill Radiatio Laboratory Series, Volume I, page 284 and pag 209, and Volume 26, page 233.

RADIO RESEARCH INSTRUMENT CO.
550 FIFTH AVE.
NEW YORK
JUDSON 6-4691

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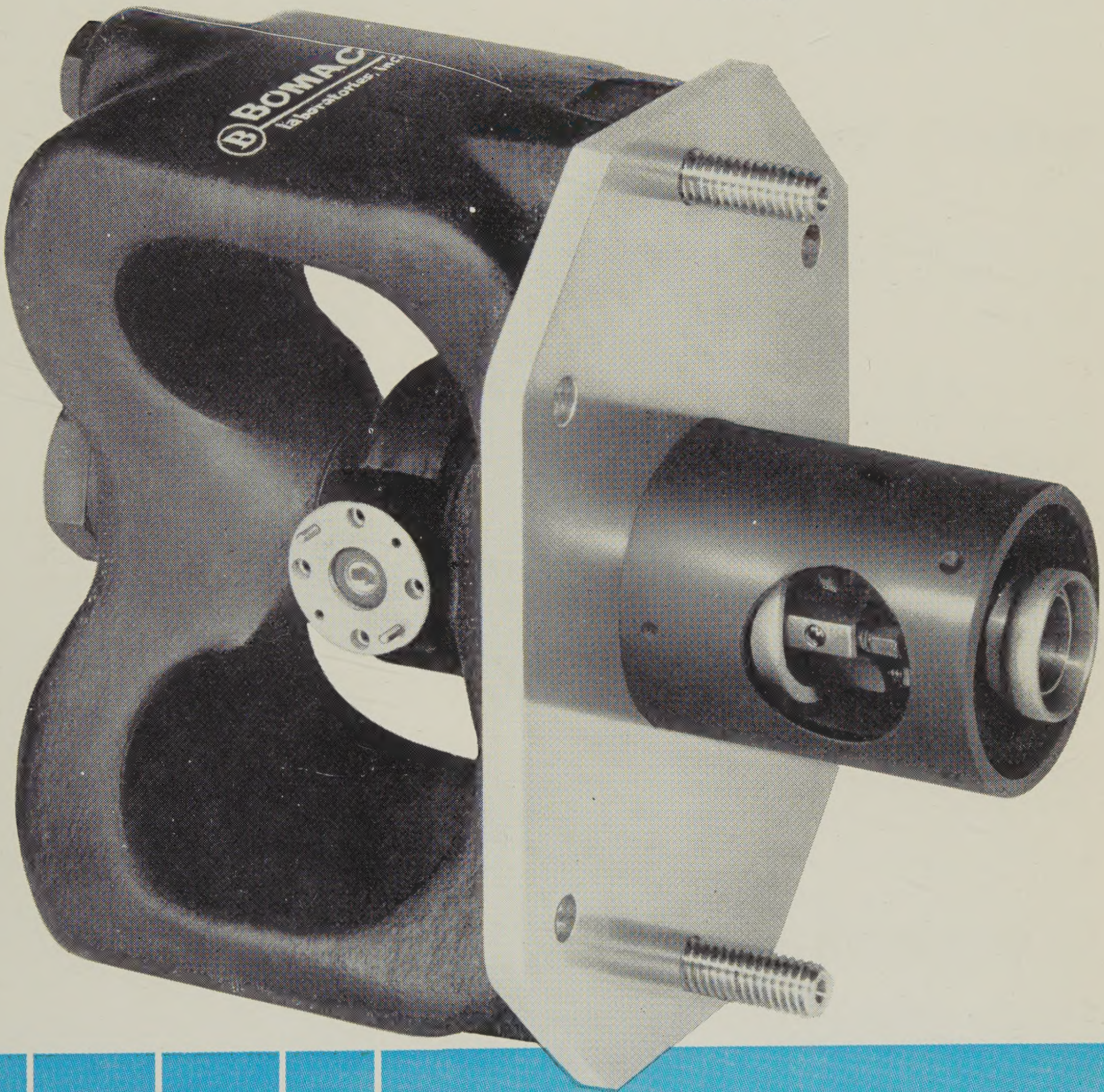
V-BAND MAGNETRONS

Life — over 700 hours reported
Peak power available — more than 10 kw. (More power than you can get from any other device at this frequency)
Duty cycle — up to 0.001. (For the BL-221, it is 0.00055)
Vibration — will survive 10 g's
Shock — 50 g's at 4 millisec
Lightweight — 7.25 lbs
Mounting — mates to modified standard flange
Ruggedized — Ceramic and metal construction
Fixed tuned

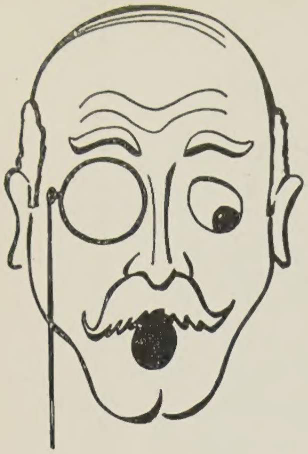


Band	Tube Type	Frequency Range (MC)	Minimum Peak Power (KW)	Output Mates with
V	BL-235	51,000–54,000	10	UG385/U
V	BL-236	54,000–57,000	10	UG385/U
V	BL-237	57,000–60,000	10	UG385/U
V	BL-221	69,000–70,500	10	UG385/U

New product catalog available. Send for your copy today.

BOMAC laboratories, inc.
SALEM ROAD • BEVERLY, MASSACHUSETTS
Offices in major cities — A subsidiary of Varian Associates.

Leaders in the design, development and manufacture of TR, ATR, Pre-TR tubes; shutters; reference cavities; crystal protectors; silicon diodes; magnetrons; klystrons; duplexers; pressurizing windows; noise source tubes; high frequency triode oscillators; surge protectors.



"Blimey, it's a bloomin' antenna"

Pardon the poetic license, but "bloomin' antenna" is probably the best way to describe Kennedy's new MOBILE TRACKER. See how, flower-fashion, the collapsible dish is quickly opened and put into operation . . .

This unique dish design, with a surface made of imported reflective plastic cloth, is but one of the many unusual features that serve to make this the most highly mobile and economical antenna yet introduced. For example:

- **The tower and dish — already joined — stow in a 24-foot trailer**
- **The gear system is designed for rapid positioning and tracking by manual operation**
- **The antenna can be operated in less than one hour after arrival at the site**
- **Elevation adjustments are from −5 degrees to +95 degrees and the antenna is capable of 360° rotation in azimuth, both clockwise or counterclockwise**

This antenna Model 1092 is available for immediate delivery. Write for complete specifications or call EVergreen 3-1200.

Kennedy Gives You Experience
You Can't Buy Elsewhere

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ANTENNA DIVISION
Cohasset, Massachusetts
EVergreen 3-1200

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MICROWAVE RESEARCH AND DEVELOPMENT • TRANSMISSION TOWERS • SWITCHYARD STRUCTURES